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ESSAYS

ON THE

Physiology of the Nervous System,

WITH AN

APPENDIX

ON

HYDROPHOBIA.

BY BENJAMIN HASKELL, M. D.,

Of Rockport, Mass.

"Mind is one, be it causal or ideal ; but it is shown in these,
The creature is constructed individual, for trial of his reasonable will,
Clay and soul commingled wisely, MINGLED, not confused :
As power is not in the Spring, till somewhat give it action,
So until spirit be infused, the organism lieth inergetic."

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ESSAY I.

INTRODUCTORY.

The doctrine of the existence of certain specific vital endowments, by which the functions appertaining to the nerves and nervous centres are performed, has long been considered as established in physiology; and its influence may be traced in the vast preponderance of the nervous system, over other organic systems and tissues, in the minds of all writers on the subject. There is scarcely a vital change or process, which takes place within the body, scarcely a mode of activity of the mind, which has not at some time or other been referred to some particular nerve, part of a nerve, or nervous centre, as its inherent cause. Secretion, muscular contractility, circulation, respiration, and even nutrition, have all, at one time or another, been supposed to derive their power from this source. There are few diseases which do not owe their virulence and danger to the mode in which they affect certain properties of the brain, spinal marrow, or the organic nervous system. There are few remedies which do not exhibit a vital affinity for some one of the same properties. Animal magnetism is discredited because there is no nerve leading from the magnetizer to the magnetized. Embryotic influences are disbelieved, because a similar connection exists not between the mother and the fœtus in utero. Sympathy cannot be conceived to take place between parts or organs, where there is no nervous medium of communication. Whatever is unexplained in physiology or pathology, is supposed to depend on some occult power of the nervous system. For as its open and admitted powers border on infinity, no limit can be assigned to the number of those which are hid. The spinal marrow has its reflex function; the medulla oblongata its respiratory and deglutitory function. The ganglia at the base of the brain are the seats of sensation, instinct, and emotion. The cerebellum has the power of co-ordinating muscular motions. The cerebrum has its automatic actions, which, according to the latest and most popular version of this physiology, comprises nearly all the functions of the soul, leaving out, in short, nothing but the will, which, owing to some peculiar obstinacy of its own, will not come into the category. All the forms of thought pass, by a mutation of words, through "ideation" into "cerebration." "Those processes," says Carpenter, "called into activity by sensorial changes—varying from the simple act of perception to the highest operations of intellectual power—consisting also in the play of fancy and imagination, and including those active states known as passions, emotions, mor-

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al feelings, sentiments, &c., must be regarded as essentially automatic
nature, and as the manifestations of the reflex activity of the cerebrum.'

The belief in such a wonderful array of powers inherent in an organi
could not obtain, without leading to the most searching investigation int
atomical structure and physiological action of the part thus endowed.
mists would naturally seek to know what were the peculiar configurati
collocations of parts, of the brain, that adapted it, by its reflex activity
duce thought, emotion, moral feelings, &c.; while physiologists would
possible, at the play of the machinery in living operation, to divine the
powers when perception takes place, or fancy is called into exercise, c
into the causes of the spontaneous combustion by which the steam is
when dire hatred or revenge rules the hour. But, unfortunately, the s
such researches has not been commensurate with the efforts expended. T
has been bisected, dissected and vivisected; it has been sliced, horizont
pendicularly, transversely and diagonally; but the radiant crystal whic
tined to shine forth, when its true cleavage is struck, like the gem of G
gy, yet lies in a dark and unfathomable cave. Its tissue has been u
and its fibres have been traced with diligent minuteness throughout thei
ramifications and decussations; but the thread which guides through t
rinth, where soul unites with body, cannot be laid hold of. The scalpe
microscope have both done their utmost. Dogs, rabbits, Guinea pigs, h
asses, have been tortured into martyrdom, by a modern scientific inquis
the responses wrung from these tortures have been exceedingly vague a
isfactory.

Every prominence on the surface of the brain, every groove and fis
received some high-sounding Greek or Latin name. The scholastic
its physiology most certainly has been attained. We have learned dis
on the cortical and medullary structure, on the vesicular and tubular p
the gelatinous and tubular fibre, on the axis cylinder and primitive ba
no connection, chemical, artistical or mechanical—no adaptation bet
structure, and the wonderful functions that are said to grow out of it—
been traced. To the unsophisticated eye, the brain, when opened into,
mysteriously simple and homogeneous. It looks in vain for a reason
cortical and tubular portions should have any more complexity of fun
the cortical and tubular portion of the kidneys. "The telescope that s
there; the whispering gallery that hears, is not there; the cabinet
framed as to remember; the loom on which the web of thought is w
cauldrons in which human passions effervesce, do not reveal themselves

In the language of the popular physiologist above quoted, if we ad
him that the brain is the fount and origin of all intellectual activity,
also admit that "sensation, thought, emotion and volition, are changes
ciable to our senses by any means of observation which we *at present* p
language which, though sufficiently despairing for the day and generat
out the hope that in the progress of the mechanic arts, some ingenio
ment may be invented, which will bring these singular processes int
with either sight, hearing, touch, taste or smell.

Nothwithstanding, however, this apparent want of success in disco
connection between the structure and vital actions of the brain, and t

posed vital properties, there seems to be a general acquiescence in the opinion, that great and important discoveries have been made, since this method of investigation was adopted. We hear, on all sides, of the great advances that have been made in nervous physiology. So well satisfied are some of the leading physiologists of Great Britain of the value and permancy of these additions to our knowledge, that they begin to discuss the meed of honor that should be awarded to those who have had a share in bringing them about. We have even the high authority of Sir Wm. Hamilton, that the results of Sir Charles Bell's investigations are beyond the risk of refutation. One can hardly repress a smile at the complacency with which Dr. Carpenter acknowledges the credit due to the continental physiologists for furnishing *details*, while he attributes to himself and his insular confreres, every material step in advance, of the *general doctrines* of the science. France, Germany and Italy have, it seems, produced the lumbermen and brickmakers, and through them the rough materials; while England claims the Carpenters, and other artificers, by whose handy work the building is "fitly framed and joined together." No son of New England would wantonly disinherit himself, by detracting from the just fame that belongs to the land of his ancestors. We claim an hereditary right, even the right of primogeniture, in all her honors, scientific and literary, as well as those won by flood and field, past, present, and to come. But in the present case, if we should barter our birthright for a mess of pottage, Esau would have the advantage of Jacob. Our portion of laurels won in the researches into the reflex and automatic powers of the brain and nervous system, is about on a par with our interest in the celebrated discoveries of Sir John Herschell in the natural history of the moon, which made so much stir in the papers a few years since.*

To be serious,—in the face of the authority of these eminent men, who hold by the ear, the one the philosophical, the other the physiological world, I believe that it can be established, that while facts and details have accumulated, they alone constitute all the progress that has been made; that not a step has been taken in advance, in the general doctrines of the science, since the time of Sir Charles Bell; that even his supposed discovery was, instead of a step in advance, a step *aside*; that, by placing what was, in reality, an attribute of mind, in a nerve, as a *vis insita*, and recognizing but a part of a truth as a whole, he has given a tangental impulse to the course of investigation, which has kept it off the track ever since. By endowing the anterior columns of the spinal marrow with a motor power, and the posterior columns with a sensitive power, he sanctioned and gave the chief impetus to subsequent inquiries into the reflex and automatic powers of the brain, ganglia and spinal cord, and the vital endowments of the nerves generally. If the mind or spiritual principle, as a real potential essence, active in the body, is lost sight of in these inquiries, it has been owing, in a great measure, to the influence of his authority.

There are but two methods of considering the nature and office of the nervous system in the human body, which present any claim to consistency in themselves, or any analogy to the forms of knowledge. Either all mental affections must be supposed to inhere in, and to depend on, vital endowments of nerves, or the supposed vital endowments of nerves are another name for mental powers or activities, associated with the physical activities of nerves. According to the former of these views, it is by virtue of a specific vital endowment of the optic nerve, that when light is impressed on the retina we are affected with the sensation of color; by a similar emdowment of the auditory, when the vibrations of the air reach the internal ear, we are affected with the sensations of sound; another of the olfactory, to which we owe the sensations of odor; a fourth endowment of the gustatory, to which we owe the sensations of taste; a fifth, imparted to the nerves distributed to the skin and the posterior part of the spinal marrow, gives the sensations of touch. The nerves that go to the muscles, and the anterior portion of the spinal marrow, have a motor endowment by which the muscles are contracted; while the central portion has its reflex endowment. The power of breathing and the power of swallowing are inherent properties of the medulla oblongata. And as all these sensations of sight, hearing, taste, &c., are as much affections of mind, as thoughts, emotions and passions, and since no connection between the structure or vital actions of the nerves and these sensations can be traced or even conceived; the mechanical relations in which indeed they differ, being such as are accommodated to the physical causes acting upon them from without; it is perfectly consistent and legitimate to transpose this reasoning to the brain and the mind in its higher faculties. The brain being a huge congeries of nerves of the same character as those of the superficies, any number of vital endowments may be predicated of it; and as the brain is not directly operated on by external or mechanical causes, there is no need of a mechanical division into parts distinct to the senses, as in the former case, in order that the analogy may hold. Not merely, then, is sensation, thought, volition, judgment, memory, imagination, with the passions and propensities, referable to vital powers or endowments of parts of the brain, but all the phrenological faculties with their craniological organs, coupled with all the additions that the phreno-mesmerizers have made, are perfectly consistent with this philosophy.

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*The reader will doubtless recollect the moon hoax, which appeared in one of the New York papers in connection with this distinguished name, and which imposed on certain savans even.

A moment's reflection must satisfy any one that this doctrine is neither more nor less than materialism. If all the mental affections, from sensation up to thought, (and there is no stopping point from the admission of one to the admission of the whole,) are dependent on properties of nerves or of the brain, to suppose the existence of mind, soul, or spiritual principle, capable of sensation, feeling or thought, is superfluous. We have no use for it in connection with the body, nor can we conceive of its enduring after death. When the nerves and brain crumble to dust, those vital endowments, dependent on their organizations, disappear along with them. Yet materialistic as it is, this is the doctrine generally acquiesced in by the medical profession throughout this country and the world. The physiological works in which it is set forth, are those which are most strongly recommended by the medical professor to his class in every school, and by the medical journals to the profession at large. Nor does the evil end here. Compilations from these works are fast being introduced into our seminaries of learning, and even into our common schools. So that, among the many new and spontaneous developements, which spring up from the present hot-bed cultivation of the minds of our youth, the next generation bids fair to exhibit in its full maturity, the growth of the principle that the brain thinks. To lay the axe at the root of the tree, that brings forth such fruit, is therefore a measure required by the best moral interests of society, as well as by medical science.

The origin of the prevalent doctrine, is to be ascribed to the universal tendency to allow the facts derived from sensible observation, to preponderate over those which are revealed by consciousness. So great is this tendency, as manifested by physiologists, that they not only are found to explain the latter by physical analogies as a general thing, but frequently suffer them to be crowded out of view entirely—not estimating them at all,—in phenomena where they play at least, as important a part as the former. It is also much heightened by the influence of a false logical principle, which though again and again exploded, still meets with advocates in high quarters, and is ever thrust forth with the captious phrases, "experience," "practical," "positive method," to fetter thought, and to keep it cramped within scientific splints. Physiology is a science where, in the functions of animal life, if not in those of organic, we can clearly recognize these two great classes of facts to meet, and to blend together. The phenomena are therefore not physical, nor mental, but mixed. The first step in the investigation of such a phenomenon is, to refer all the facts which presents the characteristics of a physical nature, to physical causes acting in accordance with physical laws; and those which resemble mental operations, to mental causes and mental laws. It is only, as we are *thus* able to refer events to their causes, that we can understand their true bearing and import and make any advance in knowledge. We must connect the cause through its law, rule, or mode of operation, with the effect, not through simple antecedence and consequence. Indeed, we have need to do this, in order to determine, often, which is the immediate antecedent, and which the consequent in such cases. Nor can we, in any other way, satisfy the idea of efficiency, or power, which we instinctively carry with us, both as a guide to the discovery, and as a test of what is the true cause. Thus, of the two antecedents of day, night and sunrise, we decide that the latter is the cause of day, because we know that it produces light, which is the essential element of day; that is, there is an efficiency in this phenomenon to give rise to day.

In the light of the principles now indicated, I wish to present to the consideration of all interested in this important subject, what I am unwilling to estimate as any thing less, than a two-fold refutation of the views generally entertained in regard to the nervous system. I propose to disprove them, by presenting a view of the connection between the mind and the nervous system, founded on the plain and obvious powers and laws of the former, as revealed by consciousness; acting by means of the simple and natural properties, which spring from the structure of the latter: and by showing, in contrasting it with the prevailing theory founded on the doctrine of vital endowments of nerves, that, while it accounts for every fact which that accounts for, it accounts for many, which a true system ought to explain, but which the one in question does not reach, and others again, which are in direct contradiction of it. These will comprise the most important facts in the anatomy, physiology, and pathology of the nervous system. I shall farther confirm this disproof, by pointing out various errors, inconsistencies, and absurdities, into which the most ingenious minds have been led by adopting and following out this theory.

In the second place, I shall endeavor to prove that, though the theory just mentioned, gave a tolerable account of the facts, so unphilosophical is the nature of the assumptions, and so imperfect is the positive evidence brought forward in support of the idea of vital properties, that no good reason exists, why we should regard them as really existing.

IDEA OF THE NERVOUS SYSTEM.

In order to prepare the way, to appreciate the office of the nervous system in its simplicity, the mind must be divested of the influence of certain terms and phrases, which in neurological works, serve to mystify the subject, if they have not their counterparts in nature. The expressions " nervous power," " nervous force," " nervous influence," stand for an idea extremely vague and floating in the minds of those that use them. And as to the existence of an energy corresponding to this idea, physiology has about the same ground for believing it, that chemistry had for believing in the principle of phlogiston, before the discovery of oxygen. So the terms " afferent" and " efferent," as implying some influence, other than physical, transmitted from the periphery to the centre, and some still different influence, generated in the centre, and transmitted to the muscles, are irrelevant. The words " motor" and " sensitive" even, when held to mean that the intrinsic action of a nerve connected with a muscle, is in any manner different from the intrinsic action of a nerve leading to a sensitive surface—as well as the words " reflex" and " automatic," which, though of later origin, figure conspicuously in our standard works, if they are intended to apply to anything more than a mere *description* of the phenomena, in reference to which they are used, are of an apochryphal character. In like manner, such phrases as, "the brain is the organ of the mind," the seat of thought and " will," and this or that " ganglion is the seat of instinct" or " emotion," however common and tongue-worn they have become, I consider an abuse of language. They are carrying ideas drawn from our knowledge of material things, into a province where they have no relation. Bodies or things extended, have seats or localities in space; but we have no *more* reason to suppose the spiritual principle to be located in the brain in thought, than we have to suppose it located in the stomach in digestion, in the gland in secretion, in the muscle in contraction, in the organ of sense in sensation—nay, I may add, in the external object in perception.

The use of such language, in the works of our most popular writers, has had a tendency to exaggerate the office of the nervous system, and to depreciate the value of the spiritual principle. The supposed vital endowments have multiplied, and have successively encroached on the province of the mind, until its office in the body has become merely titular. We are at a loss whether to call it a life membership, or a sinecure. Indeed, we are constrained to think that it is occasionally mentioned only to escape the *odium theologicum*. Such, it is not uncharitable to suppose, is the motive, when we find an author simply stating that by calling the brain the organ of the mind, he only means that it is the *instrument* through which the mind acts; and after having made this disclaimer, leaves the mind, as Uncle Toby left his declaration of love, " to shift for itself," while he goes on, referring all the operations of the intellectual faculties, and all the moral feelings too, to the reflex and automatic powers of the brain.

In what I have to say, I shall consider the mind, or spiritual agent, not as a theological abstraction, or a moral necessity, introduced into physiology as a dumb show, but as the living, active, energizing principle, from the punctum saliens, to the muscular rigidity that closes the scene. I hold, that in all the vital as well as mental operations, this principle is primary and determinative, and organic structures are secondary and accessory; and the recognition of this activity is absolutely necessary to a just appreciation of the phenomena that take place in the body, whether vital or mental, whether in health or in disease.

I regard the nervous system as simple and uniform in its function, as in its structure; that, like all the rest of the bodily organs, it is by virtue of its physical properties, which are one and the same throughout all its homologous parts, it is of use in the body, and subserves the purposes of the mind. If ever it is proper to speak of vital properties, it is in relation to those activities by which its growth takes place, its integrity is maintained in health, and it is repaired in disease. But when it is formed, the nervous fibre, whether it is an attenuated cylinder containing fluid, or a solid, performs the same office wherever it is situated, whether in the brain, spinal marrow, nerve of sense or of motion. And that office is precisely what its particular structure adapts it to perform. Such is evidently the teaching of analogy, reason and common sense. The same is true of the vesicular portion, whether it forms a ganglion at the point where the nerves that go to an organ of sensation, meet with those that proceed to the muscles which move that organ, or occupies the centre of the spinal cord, or is distributed over the surface of the convolutions of the brain, we recognize nothing but an arrangement on physical principles by which arterial blood is brought into close relation with the nervous fibre; and whatever is the natural effect of the action of arterial blood as it passes to the venous state, (in all probability a dynamic effect,) on the nervous fibre, that we are bound, by all the rules of right reasoning, to consider the true and the only function of the vesicular portion. Nothing can be more absurd than to make a mere difference of form, where the same structure is brought into similar mechanical relations with another structure, a ground of difference in function, vital or otherwise.

Of these physical properties of the nervous system, the mind avails itself, in establishing its relations of sensibility and motility with the body. And it does this, not by associating its faculty of sensibility as a whole, or its faculty of motility as a whole, with any part of the nervous system; but *particular* sensations and classes of sensations, *particular* motions and combinations of motions, are associated with the physical excitements of *particular* portions of the nervous system—a fact exemplified by the special senses, and the movements of respiration.

These associations are incidental *to two fundamental and correlative laws or general principles*, which regulate the union of the mind and the body. One of these principles is mental, the other physical. The first is, that mind governs the motions of the body as directed by sensations. The second is, that the organ on which the impression, giving rise to the guiding sensation, is made, (if not in immediate juxtaposition,) is connected by nerve with the muscle to be contracted in order to move the organ.

These two principles, which I think can be shown to be universal facts, constitute the key to the true physiology of the nervous system. With reference to the first of them, it is assumed that the action of the mind, neither in its sensitive nor voluntary department, is limited to those feelings or those volitions, which it stops to register in consciousness and thus remembers, but extends to all those phenomena, whose character of adaptation, and whose want of harmony with physical laws, prove them to be of the same mechanism, or else to lie in a sphere remote from the penetration of our faculties, and one not given us to explore.

The object of the union of the muscle to be contracted with the sensitive organ, appears to me to be, to enable the mind to avail itself of the physical property of the nerve whereby the two organs are brought, as it were, into apposition. Such would be the result, were we to suppose the physical quality of the nerve to be a power to receive and propagate minute impulses. Impressions from without would then be transmitted through the nerve and repeated on the muscular apparatus. And the attention of the mind, as held in sympathetic connection with the muscle, would be roused, just as it is, when an impression is made directly on the muscle, in any one of the peristaltic actions. All the forms of motion in the body are thus reduced to the same mechanism; and we are spared that contradiction of the law of parcimony,* which we make when we attribute one set of motions to the direct action of impressions, and another to influences generated in, and transmitted through, a nerve. In other words, the mind wills to feel at one and the same moment, the muscle that contracts, and the sensation under the direction of which it contracts; and it does this when the former is connected with the sensitive organ either by nerve or immediate contiguity.

In like manner, it corresponds with the same view, to suppose the office of the ganglion or vesicular matter to be, to unite in one the nervous fibres passing from various surfaces of relation, as the muscles on one hand,, and the organs of sense on the other. This may be conceived to be accomplished by the action of the arterial blood as it becomes deoxygenated, giving rise to minute impulses which excite a vibratory movement on the fibrils, and the interference of a new impression with which, is disseminated and felt throughout the whole mass. Thus the ganglion on the simple nervous cord may serve to unite the fibres that lead from the surface of touch of a segment, or small member, with the fibres that lead from the muscles that move that segment or member. The grey matter in the centre of the spinal marrow, unites contiguous segments and organs in associated relation, and that of the surface of the convolutions controls these minor centres, and unites in one all the nerves distributed to all the voluntary muscles and to all the organs of sense. Whether this be the true office of the blood in the grey matter, or not, one thing is pretty evident, viz., that the blood generates nothing, whether in the form of electricity, nervous power, or nervous influence, which is transmitted to the muscles. For when a nerve has been separated from its ganglionic connections some time, it will, when irritated, occasion contraction in the muscle to which it leads; a fact which proves that the ganglionic centre must act on some property already existing in the nerve, and affords nothing to the medullary fibre which it had not before.

Thus, the conclusion we come to, is that while the nerve fibre connects the organs of sense with the muscle; the ganglion connects the different fibres from a number of points of a sensitive surface, with fibres leading to a number of muscles. Were there but a single organ of sense, and a single muscle to be contracted in consequence of sensations arising from impressions, on that organ of sense, the two would be united by a nerve without a ganglion. This conclusion, which establishes the uniformity of action of the nervous system, prepares the way for an investigation of the mode in which nature builds up the nervous system, and associates the powers of the mind with it.

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*This term is happily assigned by Sir Wm. Hamilton to the old law, "that no more causes are to be introduced, than will account for the effects in philosophizing."

In the lower classes of animals, we find that motions take place, and the nervous system begins to be developed in connection with impressions made on the sense and surface of touch. The organs of the specific senses, and consequently the motions arising from impressions made on them, are of later origin. In these primitive motions, we may distinguish those, in which the part on which the impression is made, moves, from those in which is involved other parts, neighboring or more distant, or in short, the whole body. They are more perfect in their character, more direct, and more easily performed. We are justified, then, in assuming that these motions are primary, and that the mind extends its power from part to part until it acquires control over the whole. In those smaller portions, members, or segments, we find that nerves connect the surface on which tactile impressions are made, with the muscles that move that part or member, a ganglion being intermediate. We therefore infer that this ganglion and this nerve are for the motions of this part. And so with other parts. But when a neighboring part requires to be moved in consequence of a sensation arising from another part, there must either be a commissural connection between the ganglions, or a direct nerve leading from the ganglion of the latter to muscles of the former. Hence the connection between the ganglions, and the plexuses. And I may add, that it is a remarkable confirmation of the view here advanced, that the brachial and sciatic plexuses, from which the nerves come off, that are distributed to five fingers and five toes, are each of them connected with five ganglions and the corresponding segments of the spinal marrow.

In the same way as commissural connections are established between the ganglions of touch, to enable the mind to move distant parts when directed by this sense; so, when the organs of the special senses become developed and the mind wills to move distant parts, or the whole body when directed by *specific* sensations, a commissural connection is established between the ganglions at the terminations of the nerves leading from those organs, and the ganglions of touch. So that the power of the mind over the body, and the beginning of the developement of the nervous system, is laid in touch; and the other powers and developements are, as it were, superimposed on these. These commissural connections, in the invertebrata, are cords that pass from the supra-sœophageal ganglion, along the ventral chain of ganglia and those between the ganglia themselves; analogues of the former, in the vertebrata, are the anterior spinal column and roots which form the connection through the corpora striata and optic thalami with the cerebrum, with the nerves that connect with the muscles below, and by this medium connect them with the specific senses. The same nerves connect, by the posterior roots, directly with the central part of the cord, and commissurally through the posterior columns with the cerebellum. The central portions of the spinal marrow (the true spinal marrow of Marshall Hall) represents so much of the ganglionic cord of invertebrated animals as formed the union between the ganglions of neighboring or associated parts, whence arose reflex motions, while the ganglions that remain on the posterior cords are the analogues of the ganglions that united the nerves connecting the muscles and sensitive surfaces of the isolated member or segment. In like manner, the corpus striatum represents so much of the supra-œsophageal ganglion, as united the nerves leading to the ventricular cord with the olfactory; while the olfactory lobes were intermediate between the nerve of the sense of smell, and the muscles that move the organ of that sense. Again, the optic thalami represent so much of the supra-œsophageal ganglia as united the optic nerves with the nerves leading to the mass of the muscles below; while the optic tubercles performed the same office between the optic nerves and the muscles that move the eye. It may be mentioned, as confirmatory of this latter statement, that the third nerves terminate along with the optic, in the tubercula quadrigemina.

The functions of the great nervous centres, as deduced from their anatomical relations by the light of the two fundamental principles above laid down, are the following:—The cerebrum, which is but the further developement and fusion of the corpora striata and optic thalami, is the organ which the mind makes use of to govern motions when directed by the specific senses. It is connected with these senses by the optic and olfactory nerves, &c., on the one hand, and with the nerves of the muscles on the other, by the anterior columns of the spinal cord, and anterior cords or roots, so called, of the nerves. The cerebellum is the organ which the mind makes use of to govern the motions of the body when directed by the sense of touch, and it is connected both with the nerves of touch and the nerves of the muscles, by means of the posterior columns and posterior roots. The mind makes use of the cerebrum and cerebellum in its acts of conscious volition, and by their aid controls the involuntary movements. This control is sometimes lost, either by a diminution of the power furnished by these organs, as in apopletic affections—or an excess of irritating impressions acting immediately on the nerves connected with the muscles, as in tetanus—or a combined influence of irritating impressions, and weakness of the will itself, which prevents its calling forth the powers of the brain, as in hysteria.

COMPARISON OF THE PRECEDING VIEW WITH THAT OF BELL.

The common belief of vital properties of nerves which this view opposes, derives its chief support from the authority of Sir Charles Bell, whose researches are well known; and a comparison of the principles just laid down with certain physiological and pathological phenomena, in order to show the manner in which these last are elucidated by them, would naturally lead us to advert to those of that writer. In the first place, then, I would state, that the conclusions of Sir Charles Bell never flowed legitimately from his premises. In his first experiments on the fifth nerve, before he had any theory to support, or rather before his theory had assumed a definite form, he drew the inference that this nerve was for motion. This, therefore, was the natural inference; and though subsequently, when on finding that it did not tally with those he drew from his experiments on the spinal marrow, he withdrew and reversed it, still there were residual phenomena, which threw serious doubts on its correctness in its amended form. The loss of all power in the lip, in an aminal whose chief sense of touch resides in the lips, and the chief motions of which, would naturally be associated with it, the dropping of the mouth, and the drawing it to one side, seemed to indicate that something more than sensation was destroyed. Many labored attempts have been made to reconcile this contradiction by his followers. But they have not been successful. Contractions of the iris have also been produced by irritating the fifth ; some distortion is produced by paralysis of that nerve ; it sends fibres to muscles, and there are other signs of its agency in contracting certain muscles of the face, particularly the eyelids. Now all this is readily explicable on the supposition that the mind employs the fifth for touch, and those motions which it performs under the direction of touch.*

Again, if we pass from the nerves of the face, to the spinal marrow, we find his experiments at once in conflict with those of Magendie and Bellingeri. While Sir Charles inferred that the anterior cords were for motion, and the posterior for sensation, Magendie inferred that the former were for motion chiefly, and the latter for sensation chiefly ; and Bellingeri that the first were for the movements of flexion, and the last for those of extension. Scarcely anything deserving the name of an attempt to reconcile the results of those of the English, with those of the Italian physiologist, has been made. But since the discovery of the reflex function, Dr. Carpenter has endeavored, by the aid of special pleading and patchwork, to make the others coincide. By the reflex function, he explains, with some plausibility, how motions are produced, when, after section, the proximate ends of the posterior cord are irritated.† But when he explains how it is that sensation takes place through the anterior cord, he assumes the thing to be proved, and then makes use of it to prove itself. For he supposes that sensitive fibres from the posterior cord pass up from the point of union of the two cords towards the spinal marrow, not because they have been traced anatomically, but solely on the ground that dividing the posterior cord puts a stop to the exhibition of sensation when the anterior is irritated. The true question is, whether there *are* any fibres either in the anterior or posterior cords by whose vital endowments sensation

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*For a full account of Sir Charles Bell's errors in relation to the fifth nerve, the reader may consult James O'Beirne's analytical correction of that writer's views respecting the nerves of the face, re-published, in this country, in the "Register and Library of Medical and Chirurgical Science," for 1834. Dr. O'Beirne comes to the conclusion, that either the fifth nerve must be allowed to have some other office than touch, or the motor portion must extend to branches of it, not now conceded by anatomists—which last alternative he adopts. Indeed it is the chief object of his essay to prove it. The view above given accords with the first. In one of the observations quoted by him, Sir Charles himself expressly admits "*a power of holding by the lips*, independent *of the seventh nerve.*"

†The inconsequence of this conclusion is shown by an experiment of M. du Bois-Reymond. "If any motor nerve be selected which divaricates into two branches, (as, for example, the sciatic nerve of a frog, which divides above the bend of the knee into the tibial and peroneal branches,) and a galvanic stimulus be applied to either of these branches, this having been first divided above its insertion into the muscles, the electrotonic state will be developed, not merely in the portion of the trunk continuous with that branch, but also in that which is continuous with the other branch, as will be made apparent by the contraction in the muscles supplied by the latter."—(*Carpenter's Physiology, Fifth American Edition*, pp 653–4.) Here we have an undoubted instance of an irritation being transmitted through a nerve, when severed in part from its natural connections, in a manner opposite to the physiological mode of such transmission, as generally understood. Can any one say, that when the proximate ends of the posterior cords are irritated, the resultant motions through the anterior are not of an analogous character?

Again, it may be asked, how happened it that motion was lost, while the anterior column was healthy, if motion, as a whole, belongs to that portion? The answer to this inquiry is too obvious to require comment.

A third question, more pertinent to our purpose, is this—How happened a disease which was general throughout the posterior columns, and which of course must affect the general function of those columns, to produce paralysis of the inferior extremities alone? If the function of this part depended on an inherent vital endowment of it, we should have overwhelming proof that that function was to give motion to the lower extremities. But it is not thus lightly to be disposed of. That we are ordinarily guided by touch in the movements of the lower extremities, I need not waste words in proving. Our consciousness informs us of this fact. Or if it does not, pathological observations teach us that when the sense of touch is wanting, the eye has to be turned down to the extremities in order for the body to be balanced on the feet. Now, if the habitual motions of the lower extremities are directed by touch, and if the commissural connection of the surface of touch and the muscles, with the central organ, is diseased, the loss of motion would display itself here first. This explanation is directly corroborated by the observed consequences of diseases of the central organ, the cerebellum, and conversely by diseases of the cerebrum. In the work of Solly on the human brain, two cases of disease confined to the cerebellum are quoted from Serres, in which the leg on the opposite side was palsied, with comparatively little affection of the arm; and another, after Abercrombie from Morgagni, in which scirrhus of the left lobe of the cerebellum was followed by paralysis of both inferior extremities; thus showing that whether the central organ itself is diseased, or its influence is cut off by disease of its commissural connection, the effect is the same. It is also a remarkable fact that in cases of hemiplegia, where recovery takes place partially or wholly, the leg precedes the arm in the process, just about in the same proportion of cases, that the seat of effusion is in the cerebrum compared with the cerebellum. It is, as we should naturally suppose would result from the mind's recovering the power that it exerts through the cerebellum, first, in consequence of the gravamen of the disease being less felt there.

The rationale of all the varied phenomena which take place when the great centres, or their commissural connections, the anterior and posterior columns, are diseased or injured, I conceive to be this. The mind having built up and acquired its power over the muscular movements of the body in the manner above stated, employs both brains to maintain a certain degree of tension on the nerves leading to the muscles, &c., according to their respective powers. This is done by the intervention of the anterior and posterior columns. The power derived from the cerebellum is proportionately more directed to the inferior extremities, comformably to its habitual associations. That from the cerebrum is more directed towards the superior. This is in conformity to the rule, that all the works of man's hands are performed under the direction of the eye. Now in case of sudden disease of the centre, as in apoplexy—or of injury of the connecting medium, as in division of the anterior column, the power of that centre is cut off. And the mind, after making allowance for shock, being deprived of the help which it derived from that source, finds itself without the power of executing its accustomed movements. But it is a re-active principle; and for the same reason that when a large artery is tied, it sets about to restore the circulation through the smaller ones, it aims to re-acquire its lost powers; and, so far as it is successful, it re-acquires, in the order in which it originally acquired them. In most cases of injury of the spinal marrow, and in some cases of apoplexy, the patient dies before this re-active tendency developes itself. And as a much larger proportion of power is derived from the cerebrum through the anterior column, annihilation of motion would be presented in all such cases where this part was severed. A superficial view, or a view which contemplates the nerves as having vital endowments, and not as acting in subserviency to a spiritual principle, would lead to the inference that the anterior portion was destined for motion. Thus the results of disease would seem to confirm the results of experiments, and still both be wrong. But in cases of slow disorganization, the mind meets with no sudden disruption of its energizing, and often gradually accomodates itself to circumstances. Such cases would be exceptional to the former. We might meet with instances of destruction of the anterior cord and persistence of motion to a degree inexplicable on the ground of vital endowments; while we could conceive of a gradually-increased activity of the cerebellum to compensate for the lost power of the cerebrum, which would enable us to account for them.

These conclusions are also confirmed by direct experiments on the two brains. In those of Hertwig, when the upper part of the hemispheres in a bird were removed, sight and hearing were lost, but were afterwards recovered; when the whole were removed, sight, hearing, taste and smell, were lost and were never regained, although the animal lived three months. In both animals, the cerebellum being intact, signs of sensibility to touch were manifested, and also of a capability to stand and direct motions by this sense.

All those experiments, again, on the cerebellum, from which the inference has been drawn that that organ was for co-ordinating or combining the muscles, so as to produce voluntary motions, may be explained as well or better by saying that it enables the mind to govern motions by touch. Such movements as were disturbed by mutilating it, as standing, walking, balancing, &c., were evidently those which are habitually associated with this sense. The chief points of difference are, that the latter explanation exchanges a vague and indeterminate expression for a lucid philosophical principle, and brings the office of the central organ into harmony with that of its prolongation into the spinal marrow.

This unnatural separation of the office of the posterior column from that of the cerebellum, is the legitimate consequence of Sir Charles's deserting general analogy and anatomical deductions, and trusting solely to experiments, without the true key to guide him in their interpretation. It forms one of the chief objections to his system; so weighty, indeed, that Sir Wm. Hamilton takes exceptions to it alone, while, in deference to the physiologists of Europe, he gives in his adhesion to the general principle. The limited number of fibres that, according to Solly, pass from the restiform bodies to the anterior columns, cannot alter the case, although their purpose for the present is somewhat obscure. Whether they serve to connect the function of respiration, with the cerebellum—as the fact that some fibres of the portio dura come off from them would seem to indicate—there can be no doubt that the main connection of the cerebellum is with the posterior columns, and that their functions ought to harmonise.

Finally—it is admitted by Sir Charles, that the mind must be cognizant of the state of the muscles in order to regulate their contractions. And as he has a set of fibres to transmit motor impulses from the brain to them, so he must have another set to transmit sensitive impulses upward. Here he draws largely on the imagination, and both motor and sensitive impulses are inventions to begin with. And what anatomist has ever traced two classes of fibres, that lose themselves in the muscular structure, one of which on being irritated gave rise to muscular contractions alone, and the other to sensations? Some late physiologists have improved on this idea, and have invented a third fibre to account for the reflex motions, in accordance with the rule, that for every specific endowment a distinct fibre is necessary. But this process of laying up the nervous fibres, like the laying up of a rope with three strands, is found, by the knowing ones, to hazard the inconvenience of rendering the whole cord unwieldy, by its size. And it may be seen, by the last edition of Carpenter, that this branch of manufacture has fallen into disrepute. It is, however, of little consequence logically, how many of these fibres with specific endowments are called into being. One class only is necessary to hold the mind in relation with the muscle, according to the view given above. To imagine, therefore, a series of fibres for motor impulses, and another to render the mind cognizant of the state of the muscles, is to introduce two causes to account for that, for which one will account as well.

To recapitulate :—The view of the nervous system promulgated by Sir Charles Bell, does not, in the first place, exhaust, or give a full account of the contents of the experiments and pathological observations on which it is based, inasmuch as some phenomena are unexplained by it. In the second, it is not necessitated by those phenomena which it does explain, inasmuch as they can be explained by another supposition. In the third, it is directly contradicted by pathological facts, so admitted by its own supporters. In the fourth, it divides in function, parts anatomically united in structure. And in the fifth, it violates an important philosophical law, by unnecessarily multiplying secondary causes.

In view of these facts it may be safely said, that among the mysteries connected with the nervous system, not the least is the circumstance that the medical profession as a body should settle down in the belief that this view presented the sum and substance of all truth in the department which it treats, and formed the starting point for all future investigations.

CORROBORATION OF THE VIEWS ADVANCED.

A further and somewhat singular confirmation of the idea above given of the functions of the anterior and posterior columns of the spinal cord, is derived from the following observations of Sir B. C. Brodie on injuries of that organ.

"The lower limbs are more frequently paralyzed than the upper, even when the lower part of the cervical spine has been injured. This circumstance is remarkable, as it is contrary to what happens when the functions of the spinal cord are interrupted in consequence of caries of the cervical vertebræ. In these last cases, the paralysis is often complete in the upper limbs for many weeks, or even months, before it extends to the lower. Paralysis of the upper limbs has been known to follow contusion of the dorsal vertebræ."

These facts, which seem inexplicable on the common theory, are easily understood, when we consider that caries, affecting the bodies of the vertebræ, must involve the anterior columns some time before the posterior; whereas in injuries, the processes are usually the first to suffer fracture or dislocation, and the posterior columns which are most concerned in the movements of the lower extremities, being nearly contiguous, will soonest feel the effects, and will therefore be most likely to be disturbed in their function.

In No. 19 of Braithwaite's Retrospect is an account of a discussion before the London Medical and Chirurgical Society, in which Marshall Hall took part, relative to a case in which there was palsy confined to the arms. The doctor was evidently at fault in his explanation of the case, simply because there was not room for it in his philosophy. According to his ideas, it was "almost impossible to imagine disease of the spinal marrow so situated as to induce paraplegia of both superior extremities, without involving in its effects the parts situated below."—After what has been said above,* it is unnecessary for me to enlarge upon such a case.

It is not difficult to understand how contractions of the muscles may take place when the anterior cords are irritated, and fail to be produced when the posterior are excited, without necessitating the conclusion ordinarily drawn from these facts. If we suppose the anterior cords to minister to those motions which are executed under the direction of the specific senses, and the posterior to be connected with general sensation, and those motions performed under its direction, it is plain that the functional activity of the former is *never* exercised except in connection with muscular contraction. Whereas the same activity of the latter, being exercised for sensation as well, will often take place without such contraction. For the mind, after receiving the sensation, deliberates and decides whether it will contract the muscle or not. In the one case, an associative connection will be formed between the excitement of the nerve and the contraction of the muscle, which will have no place in the other. This associative connection may display itself on irritating the nerve, when separated from its centre by the contraction. We are not without facts to sustain this position. Irritation of the third nerve often fails to produce contraction of the iris, owing, as it is suggested by Longet, to its filaments having to pass through a ganglion; and when it does contract the iris, the contraction continues after the withdrawal of the stimulus, which is not the case with the contractions of the voluntary muscles simultaneously excited by stimulating the same nerve. This last fact is explicable, says Volkman, only by supposing the voluntary muscles to be excited directly through the nerves, while the iris is excited through the ophthalmic ganglion as a centre. Now what the ophthalmic ganglion is to the short branch of the third nerve, in the main, the ganglions on the posterior cords are to their connecting fibres with the spinal marrow. And it by no means follows, because it is difficult to excite contractions by irritating these fibres in a mangled dog, that they have nothing to do with muscular action.

That philosophy is questionable, which argues from the contraction of the muscles on irritating its nerve, to the regular and ordered movements of the body. Were the nerve stimulus the only one that excited the contractility of the muscle, it would be more plausible. But we find that galvanism, chemical and mechanical irritants, applied to the muscle, also excite it. Indeed, live muscle responds in no other way, than by contraction, to any stimulus whatever. It is easy to conceive of a trembling or vibration being communicated to the nerve, by mechanical irritation, and propagated down to the muscular fibres, where, by means of the peculiar blending of these fibres with the nervous, it is felt as though it was directly impressed upon it. The muscular contraction following, would then be an incidental effect of the mere mechanical properties of the nerve, and of the irritability of the muscle. The only fact thus left to us by which we infer the agency of the nerve in muscular contraction, is its being interposed between the muscle and the centre;* and we are left at liberty to inquire whether this interposition is to connect the muscle through that centre with other nerves, and through them with other muscles and organs of sense, or whether some unknown and inconceivable impulse is generated in the centre, which passes down the nerve to the muscle. The character of the contraction thus excited is spasmodic, irritative, while the action of the muscle in movements, involuntary as well as voluntary, comprehends both contraction and relaxation, and is one of control.

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* On the connection between the motions of the arm and the specific senses, and through them with the cerebrum and anterior columns.

If it be said that mechanical irritation of a muscle through a nerve is followed by its contraction, it may be said, in reply, so are all irritations of the muscle. If it be said that the muscle contracts when stimulated through the nerve, it may be also said, in reply, that it always contracts on the application of stimuli. And what is more to the purpose, not only do individual muscles contract by other stimuli than that (if such exists) which comes through the nerves, but groups of muscles, which having had certain combinations in their contractions, formed, during life, while their connections with the nerves and nervous centres continued, have exhibited the same after death, before their irritability had subsided, and after separation from their nervous centres by division of the nerves. Are we, then, to suppose the existence of a double mechanism, by which (to say nothing of the peristaltic motions) the movements of the body are effected; one by the nerves and nervous centres, and another and ulterior one? And if this last, of necessity, *must be*, does it not follow that the first must *not* be? Undoubtedly, the muscular contractions and combined movements witnessed by Dowler and Brown Sequard, in their experiments, take place according to the same laws that govern all motions in the living body. And those who maintain the contrary, imagining, from seeing the nerve interposed between the muscle and the sensitive surface, that some influence passes down to the muscle to cause it to contract, are imposed on by appearances, in the same way as those, who, from seeing the image on the retina, infer that that is what we perceive in vision, whereas it is the external object. Were it the picture, we should both see it double and in the inverted position. The role of the nervous system would then be, to furnish certain facilities and conveniences for the execution of these laws, but not the essential conditions.

Another objection is founded on the fact of these experiments not being exact copies of physiological impressions. They are made on the cords of the nerves, while the impressions, which in the natural state excite motions, are made on surfaces on which their peripheral extremities terminate. They are therefore at best of a second-hand nature, and correspond with what is called hearsay evidence in law, which, as all know, will not be admitted in a court of justice. We are, moreover, not without high authority for the assertion, that they are very imperfect copies of the originals. "It is to be observed," says Carpenter, "that a slight irritation applied to the peripheral extremities of the afferent nerves, is a more powerful excitor of reflex action than a much stronger impression, which occasions acute pain, applied to their trunks." And in some cases there is reason to suppose that in the former way they can be excited, while they cannot at all in the latter. Narcotics, while they act energetically on the surface to which the extremities are distributed, produce no such effect on the larger trunks. Neither do acids.

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* Aside from this, there is as much reason to suppose that salts, acids, galvanism, &c., contract the muscles in our movements, as nervous influence.

No one could be more alive to the imperfections of this kind of reasoning, than Sir Charles Bell himself. "In a foreign review of my former papers"—says he, in the one of June 19th, 1823—"the results have been considered as a further proof in favor of experiments. They are, on the contrary, deductions from anatomy; and I have had recourse to experiments, not to form my own opinions, but to impress them on others. It must be my apology, that my utmost efforts of persuasion were lost, while I urged my statements on the grounds of anatomy alone. I have made few experiments; they have been simple and easily performed, and I hope are decisive." And again—"The whole history of medical literature proves, that no solid or permanent advantage is to be gained, either to medical or general science, by physiological experiments unconnected with anatomy." And still further—"Experiments have never been the means of discovery; and a survey of what has been attempted of late years in physiology will prove, that the opening of living animals has done more to perpetuate error, than to confirm the just views taken from the study of anatomy and natural motions." Thus far Sir Charles Bell.* Dr. Carpenter differs from him a little, in laying more stress upon *comparative* anatomy. According to him, "it is only in fact by studying the cerebro-spinal apparatus in its lowest as well as in its highest form, and by bringing the intervening grades into comparison with both extremes, that it is possible to establish what are its fundamental and essential, and what its accessory parts; and in this way only, can such a correspondence be established between the developement of a particular structure, and the manifestation of a certain psychical endowment, as may enable the *latter to be attributed with any degree of probability to the former*. In fact, there is no part of the human organism as to which the advantages of such a comparison are so striking, or in which the value of the 'experiments ready prepared for us by nature,' is so much above that of the results of artificial mutilations."

Here, then, is the testimony of both these distinguished writers against experiments. There was evidently a misgiving in the mind of each, that possibly hereafter the conclusions founded on them might not prove as solid as specious. Yet if any student of either should be questioned why he believes that the posterior nerves were for sensation and the anterior for motion, or that the cerebellum was for combining muscular motions, he would reply, "from the results of experiments" as given in the works of his master! But if experiments are not reliable, neither will their retreat to anatomy afford them greater security. Anatomy alone can merely suggest, by a difference in structure, that there might be a difference in function between two nerves or classes of nerves, but cannot tell in what that difference consists. Nor will comparative anatomy, by pointing out the correspondence between the developement of a particular structure and the manifestation of a particular faculty, warrant us in referring this last "as a psychical endowment to the former." A dozen explanations might be afforded of this connection as plausible as this. What is wanted, is a correct psychology to be applied both to the results of experiments and to variations in the structure, origin and distribution of the nerves—a correct comparative psychology as well as human.

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* These extracts, more than the temporary success of his theory, prove him to have been a philosopher.

An illustration of the danger of trusting to anatomy exclusively, without the true key to guide us in interpreting its variations, is found in the celebrated "nervous circle between the muscle and the brain," of Sir Charles Bell. He was led to this, by finding, *unexpectedly*, that a large portion of the fifth nerve terminated in muscles, which, as he demonstrated it to be a sensitive nerve, was somewhat of a puzzle. According to him, the fifth nerve sends more branches to the muscles, than to the skin; and what is more remarkable, it sends more branches to the muscles than the seventh, which is a motor nerve. For these facts he must invent a reason. Supposing the mind to be seated in the brain, and transmitting its influence down by the motor nerve, and the nerve having no power to transmit influences but in one direction, (all of which are suppositions without proof,) there was no road back; and as it was necessary for the mind to have a knowledge of the condition of the muscle, the fifth nerve was made the avenue for the communication of this knowledge. An apparently clumsy contrivance, in which the works of God appear to disadvantage, when compared with the works of man; for a messenger sent from place to place on a road made by human means, can generally return by the same way he went.

A simple explanation of these facts is afforded by the doctrine that the ganglionic portion of the fifth is a mixed nerve; that is, for touch, and the motions which the mind performs under the direction of touch. It is to be observed, in this connection, that the branches of the seventh are sent in the greatest proportion to the superficial muscles of the face; while the branches of the fifth are distributed in a similar proportion to the deep seated, especially to the muscles of mastication. The superficial muscles are most active in the movements of expression, which are associated with those of respiration; and the seventh nerve, though in man a nerve of volition, had originally its connections formed by virtue of this relation. But in mastication we are guided by the impressions made on the teeth, and on the whole internal surface of the mouth. In those acts expressed by the term biting, as when an animal seizes his prey, the visual are the guiding sensations. In the former, the nerves distributed to the muscles through the ganglionic portion of the fifth, are instrumental, inasmuch as they connect them with the sensitive surface on which the impressions are made, giving rise to the associated sensations. In the latter, the small branch of the fifth, or, as it is called, the motor, is instrumental, as it connects them, through the cerebrum, with the eye. This is in accordance with a principle maintained by Sir Charles Bell, (see his "Respiratory System of Nerves,") as well as by Carpenter, who still maintains the idea of the nervous circle, which, however, is repudiated by Marshall Hall.

Having given this instance where Sir Charles's consistency in relying on anatomy alone, misled him, I shall give another, where Dr. Carpenter's inconsistency in not relying on comparative anatomy in opposition to "artificial mutilations," has placed him in a similar predicament. It has long been the prevailing opinion, from the fact that when the par vagum is cut above the origin of the inferior laryngeal nerves, suffocation frequently follows from spasmodic closure of the glottis, that the superior laryngeals had something to do with the constriction of that part. But lately, Dr. C., on the authority of Dr. J. Reid, a favorite experimenter with him, affirms that the superior is the excitor or afferent, while the inferior is the motor nerve. Although it is found to connect with the crico-thyroid muscle by his own admission, and with the arytenoid and inferior constrictor according to other dissectors, and even inosculates with the inferior laryngeal, yet it has nothing to do with muscular motion, but is a sensitive nerve.

The laryngismus, after cutting the recurrent nerves, is attributed to palsy. And some countenance to this opinion is supposed to be derived from the collapse of the glottis, in powerful suction through the windpipe in the dead body. The action, however, is evidently much more like that excited through a nerve, when the power of a balancing nerve (to use the common expression) is taken away. As, when the portio dura of one side is cut, there is little distortion at first, owing to the restraining power of the fifth ; but when the muscles of respiration are called into exercise, as in speaking, laughing, &c., the distortion is very evident, owing to the muscles on the sound side not being balanced by those of the opposite. It is remarkable that laryngismus should be attributed to palsy of the recurrent nerves, when the cause has been irritative to those nerves ; and when there *should have been* loss of voice, which must depend on that nerve—an event which did not happen in several cases of laryngismus stridulus which have been attributed to this cause, or, if it did, was not mentioned.* It seems to me that the natural inference from Dr. Reid's experiments, is, that they were instituted for the purpose of compressing the superior laryngeals within the limits of the sensitive and motor theory.

An unprejudiced inquirer after truth, before grounding his faith on such manipulations, even with Dr. Carpenter's endorsement of Dr. Reid's accuracy, would be inclined to look at the "experiments ready prepared for us by nature," to see if they did not throw some light on the subject. Fortunately, there occurs a singular class of facts, in a lower tribe of animals, which bear on this very point. In birds, the larynx is placed at the bottom of the windpipe, and to it the inferior laryngeals are distributed. At the top of the windpipe is what corresponds to the superior laryngeal. As a matter of course, the inferior laryngeals are concerned in those motions which properly belong to the larynx, in association with the lungs, such as those connected with the voice, &c. ; while at the top, provision is made to prevent the entrance of all irritating substances into the windpipe. The nerve found at this part, viz., the superior larnygeal, must minister to this function. It must therefore be both sensitive and motor. But when the larynx rises from the bottom to the top of the trachea, the muscular provisions for both these offices become blended. The inferior becomes the recurrent, and its branches inosculate with the superior, and supply some, at least, of the same muscles. But still the original function is performed through the same nerve ; an illustration, in another form, of the above-mentioned principle of Bell, which has the sanction of Dr. Carpenter himself, as follows. Speaking of the accomplishment of acts of respiration and mastication by the same muscles, when supplied by different nerves, he attributes them to an original association with those nerves, while as yet, in the invertebrated class, all the parts were distinct, and thus proceeds : "Now in the vertebrata, the distinct organs have been so far blended together, that the same muscles serve the purposes of both ; but the different sets of movements of these muscles are excited by different nerves ; and the effect of division of either nerve is to throw the muscle out of connection with the function to which that nerve previously rendered it subservient—as much as if the muscle were separated from the nervous system altogether." All this is undoubtedly true ; but it has a more extended application than physiologists have hitherto supposed. Whenever a muscle has more than one nerve terminate in it, it is because the movements which that muscle takes part in performing were originally associated with more than one class of sensations. The union of the posterior and anterior nerves in the class of voluntary muscles, arises from the fact of the motions regulated by specific sensation being superimposed on those regulated by touch. The muscles being first developed with their nerves running between them and the surface of touch, were subsequently compelled to have established nerves running between them and the organs of the senses. But the motions originally associated with touch are still performed through the same association, and require the same medium. One of these classes of motions regulates the opening of the larynx ; and incidental to it are all those convulsive motions, whether dependent on irritation of the laryngeal surface or remote surfaces, and which play so important a part in croup, hooping cough, epilepsy, &c.

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* A case of cancer of the œsophagus is given in Braithwaite's Retrospect, vol. xxx, page 135, in which the disease involved the recurrent nerves. There was complete destruction of those nerves, and even the muscles to which they were distributed had undergone degeneration in consequence of disuse. Here then was an instance, in which, if spasm of the glottis depended on palsy of the inferior laryngeal nerves, it would show itself. Yet it was expressly stated that there was no spasm nor stridor throughout the disease. One such case is more to the point, then all the experiments ever performed.

I believe it may be stated with confidence, that there is no proof, nor any thing like proof, in physiological experiments, as they now stand, of any influence, impulse, or whatever it may be called, generated in the brain, ganglion, or any other nervous centre, and passing down a nervous cord to a muscle to excite it to contraction in movements, voluntary or involuntary. Anatomy merely shows a nerve connection between the muscles with each other on the one hand, and with the organs of the senses on the other. And when the physiologist bases his reasoning on any thing more than what may naturally be supposed to flow from the physical properties of the nerves, he argues from a baseless assumption.

Having, as I conceive, shown this in the present division, I shall, in the next essay show the utter absurdity of such an idea as the brain or any nervous centre generating these impulses, from the number, complexity of combination, variety and rapidity of changes in the muscles contracting in voluntary movements, and other considerations. But before concluding, I shall advert to another point, chiefly because one of very high authority has lent his influence, (as I believe from inadvertence,) to the support of this notion.

It is asserted by this class of physiologists, that because we are only conscious of the act of willing, before we perceive by external observation the movement of the body, all that intervenes is the result of the action of this automatic nervous mechanism on the muscles. Sir William Hamilton has analyzed the process, and takes for granted both the existence of the motor and sensitive influence between the muscles and the brain as necessary steps in it. In doing this, Sir William has evidently yielded his better judgment to what he considered as established points in physiology. For he says, "It might seem at first sight—1st, that the organic movement is immediately determined by the enorganic volition; and 2d, that we are immediately conscious of the organic nisus in itself." And again, he has repeatedly intimated in his work, his opinion that the doctrine of the mind being seated in the brain is an error, and expressed his conviction that it was in some mysterious manner present to all the organs, and actuating each in the performance of its function. Now if the mind is present to all the organs, and actuating each in the performance of its function, it must be present to the muscle and actuate it in contraction, for to contract is its function. And if so, what need is there of an influence sent from the brain along the nerve to the muscle to cause it to contract, or of another sent back to the brain from the muscle, to tell the mind when and how much it has contracted, when the seat of the mind is not in the brain? This very learned and acute author may rest assured that what seems true at first sight, is true at second sight; and that there is no more ground for supposing these influences than there was in the time of Descartes for assuming the representative idea, a modification of the brain. And the period is not very distant when it will be regarded as an error of the same kind.

CAUSES WHICH CONTRIBUTED TO THE RECEPTION AND CONTINUED POPULARITY OF SIR CHARLES BELL'S THEORY; CONSEQUENCES TO WHICH IT HAS LED.

The observations made in the two preceding divisions, enable us to estimate at their true value the experiments and reasonings of Sir Charles Bell, and the influence they have had on the subsequent progress of physiology. "The key to the system," says he, "will be found in the simple proposition, that each filament or track of nervous matter has its peculiar endowment, independently of the others which are bound up along with it; and that it continues to have the same endowment throughout its whole length." Here was his fundamental error. Long previous to his time, it had been suspected, from the occasional occurrence of paralysis of motion without loss of sensation, and the reverse, that different nerves were somehow subservient to these different functions. But the old physiologists who held this notion did not, as a general thing, any the less believe that both motion and sensation were functions of the mind, and not of the nerves. To him it was left to transfer, by a single stroke of his pen, these powers, from the province of the mind, and locate them in the nerves, as functions, springing from these imaginary vital endowments. And we look in vain in his works for any process of reasoning, grounded on physiological or psychological facts, to warrant the step. It was an assumption, neither more nor less; and it was an assumption, the necessity for which, it was incumbent on him to show, before he proceeded to experiment. Had he done this, his experiments would have been pertinent to prove *which* class of nerves were for motion, and *which* for sensation.

But as they now stand, they prove nothing. It has been already shown, that though the anterior cords are, according to his experiments, subservient to motion, they are *indirectly* so; that they are not subservient to *all* motion; and that though the posterior cords are concerned in sensation, they are not *all* for sensation, something more than sensation being accomplished through their agency.* Sir Charles, however, being fully impressed with the truth of his assumption, as soon as he found a class of nerves, the irritation of which was followed by muscular contraction; and another, the irritation of which was followed by signs of sensibility, sought no farther. He had found what he was looking after. He never stopped to inquire whether the contraction of the muscle on irritating the anterior cord might not be a particular instance of a more general fact; nor did he think of inquiring whether the sensibility exhibited was the *whole* function of the posterior nerve, but jumped at once to the conclusion with which his mind was previously magnetized. And in so doing, he overleaped the ganglion entirely. Or, if he allowed his thoughts to dwell on it for a moment, it was only to contemplate it as a sort of label, which the Creator had, in his generosity to perplexed physiologists, affixed to the sensitive nerves, to enable them to distinguish these from the motor. The size of the posterior cord being larger than the anterior cord, which subsequently suggested to Spurzheim the query whether the whole story was told in regard to the two classes of nerves, suggested nothing of the kind to him. Nor did the different degrees of obliquity, with which the fibres of the two cords enter the spinal column, nor the connection of the posterior with the cerebellum and the anterior with the cerebrum, unfold to his view any more extended system of relations.

It was in this way that he misled himself and physiologists generally. He saw a part of the truth, and mistook it for the whole. His system seemed to give an explanation of some pathological phenomena hitherto not understood, and soon began to be regarded with favor. Those cases of loss of motion where the motor nerve was sound, and the supposed sensitive nerve was divided, were plausibly explained by the loss of the guiding sensation. The anatomical contradiction contained in the distribution of a sensitive nerve largely to muscles, was met by the ingenious device of the nervous circle, which required a sensitive nerve to go to the muscle as well as a motor one. These being admitted, it became difficult to disprove it, were it false. It would naturally require time before authentic and well observed facts would accumulate sufficient to overthrow it. And when that time came, the scientific were everywhere committed. The makers of physiological systems had arranged their statistics and constructed their works according to the principle of classification which this theory afforded them. The Reviews had promulgated it to the profession, and to the world at large, as a fixed fact. And grave professors had stood sponsors for it before successive editions of the medical class in a thousand schools. A spirit of conservatism had arisen, sufficiently strong to antagonize the spirit of inductive philosophy. The question was not, what was the true meaning of a new fact, but how could it be *reconciled* to Sir C. Bell's doctrine. In addition to which, a species of sectional prejudice in the republic of letters, resisted all change. The rivalry between the nations of Europe in scientific discovery, had identified the national honor with this theory. British pride and British patriotism were interested in upholding it. And as British journalists claimed to dispense physiological facts and principles to all who read the English language, such facts could scarcely reach the mass of the profession until their obvious bearing and import had been explained away. "Cases have occurred," says Carpenter, "in which complete destruction of the anterior columns appeared to have taken place, without loss of motion in the parts below; whilst a similar destruction of the posterior columns has occurred without corresponding lesion of sensibility." Yet these cases have not been held as indicating the necessity for a wider and more comprehensive view of the nature of the office of the nervous system than Sir Charles Bell's theory presents.

We are told that we know not to what extent the nervous structure may be disorganized and its function continue. And we are gravely asked to believe, that the nervous influence, in its travels to and from the brain, can *jump across an inch or so of disorganized spinal marrow*, if it chance to meet with that amount of interruption of continuity.* A better alternative is, to believe that a theory which makes such a demand upon our faith, however well established it may be supposed to be, must be without foundation.

If any further proof is wanting of the erroneousness of these views, it may be derived from the absurd consequences that have followed them. A tree is known by its fruits. A scientific principle is seldom limited to the birth of a single discovery. It is pregnant with a generation: a progeny formed after the pattern types in nature, if true; a body of monstrosities, if false. The favor with which the supposed discovery of Bell was received, gave popularity to the principle on which it was founded. If each fibre of the nerve has its specific endowment, then each ganglion or nervous centre has one also; each fibre of the cerebrum, cerebellum and spinal marrow, is similarly gifted; and a general search commenced to find these properties out.

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* At page 669 of the fifth American edition of his work, Dr. Carpenter refers to a "case recorded in the Medico-Chirurgical Transactions, vol. xxxiv., in which a portion of the cord, at least an inch long, situated opposite the third and fourth dorsal vertebræ, was so soft that the slightest pressure of the fingers broke it up, being nearly in a fluid state through its whole thickness; yet the patient felt pain in his lower limbs, showing that the power of *upward* transmission remained. And although he had lost all voluntary control over the muscles of the lower part of the body, yet they were affected with incessant choreic movements, (which, as will be shown hereafter, Sect. 7, appears to originate in the sensory ganglia,) and these movements were affected in such a manner by emotions as plainly to indicate the downward transmission of motor power."

And this case he makes use of, to render it probable that complete destruction of the anterior columns, without loss of motion and complete destruction of the posterior columns, without loss of sensibility, is no disproof of Sir Charles Bell's theory. Although it would amount to little, if he could prove that in this case there was an upward and downward transmission of sensitive and motor influence throughout the diseased portion, he is far from making it out. The seat of pain is not in the brain, but in the mind. The seat of emotion is not in the brain, or the sensory ganglia, but in the mind. Both pain and emotion affect the mind (as has been said before) more deeply than the range of those sensations and motions which the mind receives, and performs, through the instrumentality of the brain and the columns. And if the communication through the spinal marrow is cut off, it does not, therefore, follow that communication between above and below, through the mind, is also cut off; especially, if the former disruption takes place by a slow process of disease. Reflex movements, choreic or otherwise, are still, like all other movements, performed by the mind. They are those which the mind performs involuntarily, or without consciousness of its volition. Emotions, we all know, extend so far as to produce perturbations of our involuntary, as well as of our voluntary movements. And it is by no means impossible, that by an inverse method, an obscure sense of pain may reach consciousness, when there has been no sudden break in its relations. Certainly, it is the part of wisdom to believe this, rather than to believe a theory which takes away all meaning from organization; which makes a function to grow out of vital endowments of a part, and which holds on to the function after the part ceases to exist. Besides, there is reason to believe that the feeling of pain is more connected with the central portion of the spinal marrow than any other part. And in the case in question, this portion was healthy for a great extent below the seat of lesion.

Marshall Hall was the first to discover a series of movements, in which the muscles performing them were connected with the surface of sensitive impressions through the spinal marrow alone. He therefore, consistently with this view, imagined a new endowment of this part, and a new set of fibres with specific powers to be set in operation by it. The term reflex was adopted to characterize this occult power; and was also found convenient to comprehend the phenomena. Had this word been used in this latter sense only, for the purpose of defining and enabling physiologists to reason respecting phenomena, of the nature of which they were ignorant, no objection could be made. But when a word which is definitive, or descriptive of one class of phenomena, is made the cause of another, then confusion must result. Hard words and scientific terms multiply, but they stand not for clear thoughts in the mind of the writer, and they cannot excite clear thoughts in the mind of the reader. The term reflex found synonyms in the words automatic, excito-motor, diastaltic, &c. Great parts of speech, undoubtedly! But, like the unknown quantities in algebra, they yield nothing unless something known is substituted for them.

The conclusions of Marshall Hall were at first adopted by other physiologists. But as successive supposed discoveries of the same sort followed, it began to be suspected that the multiplication of nervous filaments necessary to carry out the hypothesis, would increase the size of the nerve to an extent which ocular inspection would not warrant. They therefore located the new specific properties in the centres, leaving the generic moving power in the nerves; so that the fibres were motor to all comers, and all the movements of the body were soon classified under the terms excito-motor, sensori-motor, emotional-motor, ideo-motor, volitional-motor, according to the several centres from which they originate. It must be confessed that this arrangement has one advantage, at least, to recommend it to popular belief. It looks, (to use a nautical phrase,) it looks ship-shape. The nervous filament, like the common sailor, stands ready to obey the orders of each and every one of his superior officers. As he is motor to the excitor-midshipman, to the sensori 3d, to the emotional 2d, to the ideo 1st lieutenants, and to the volitional captain, the only man on board who has a will of his own, so is the filament to the excitor marrow, to the sensory ganglia, to the idea-generating cerebrum, and to the willing head at large.

Pursuing the same course of reasoning, if all those operations by which the mind was formerly supposed to maintain its relations with the outward world, are only reflex operations of nervous ganglia, why may not *all* the operations of the mind be dependent on a similar mechanism? The brain, in the vastness of its unexplored depths, furnished room for any number of reflex or automatic actions. If nobody could see how, why or wherefore these resulted in mental processes, nobody could see how, why or wherefore they did not, and this was evidence enough. Accordingly it was soon found that perception and judgment, memory, fancy and imagination, passions and emotions, moral feelings and sentiments, were simply the results of the reflex operations of the brain. All this seemed plausible. But the affair grew somewhat awkward towards the close. Materialism was eschewed by this school. Something clearly, purely psychical must be developed, or strange suspicions would arise. A distinction must be made, though without a difference; even, though it broke the unity of the plot. This distinction was made in favor of the will. The will was not dependent on the brain, though consciousness was. The will was permitted to rear itself unscathed, in solitary grandeur, above the wreck of mind and crush of metaphysics. Will, without perception—will, without memory—will, without passion, hope, fear or remorse, was soul; and might reasonably expect a blessed immortality. And this is styled by its learned author a compromise,—a splitting the difference between spiritualism and materialism.

Such were the consequences of the abuse of the term reflex—a term which was legitimately used, only when it was made to define a class of phenomena the nature of which was not understood. Had it been confined to this limitation, no harm as aforesaid would have arisen from it. But when it became expressive of a vital endowment of a nervous centre, and was subsequently transferred to other centres to express *their* supposed endowments, there was no stopping place until all the powers of the mind were absorbed. From being a definition of an effect, it became descriptive of cause. And as no definite idea of the nature of that cause could be reached by our limited faculties, the term itself became cause, and soon formed our whole notion of it.

I need not remind the reader, that in the foregoing remarks I have had in view chiefly the two hundred or more pages of the last edition of Dr. Carpenter's work on the functions of the nervous system. This is an attempt, by the most ingenious physiological writer of the present day, to systematize the mental phenomena that take place in connection with the body, by following out to its last result the principle of Bell, through all the modifications it has received at the hands of Marshall Hall and other British physiologists. That he has not succeeded in introducing order in the midst of so great confusion, is not so much his fault, as it is the fault of his leading idea; for that being without foundation, nothing with a stable foundation can be built upon it. With all respect for the character and abilities of this author, as shown in other parts of his work, it is due to truth to say, that he has here confounded in one heterogeneous mixture the properties of matter and mind; that he has, as it were, *knocked into pi* the facts of observation along with the facts of consciousness; that he eliminates nothing clearly and conclusively; that he clips and trims his facts to suit the ends he has in view, instead of presenting them in their natural relations; that his definitions half cover what they are thrown over; that he does not even appreciate the nature of sensation or consciousness; that he makes assertions and assumptions without the least foundation; that his show of reasoning is but a play upon words; in short, that the proper title for his work is, instead of the functions of the nervous system, "So much of the physiology of the nervous system as can be explained by the terms reflex, automatic, excito-motor, sensori-motor, mind-force, nerve-force, &c." To call it jargon, would be to use a harsh expression; and yet it would only anticipate the verdict of posterity. The dedication of his work on comparative physiology to Sir John F. W. Herschell, was a mark of gratitude for the benefits he had derived from the study of his exposition of the modern method of philosophizing; and here, in his human physiology, we have demonstrated how much reason he had to be grateful. Nor does he stand alone in his glory. When we consider the great popularity of this work on both sides of the Atlantic—the almost universal laudation it has met with from all branches of the profession, we never need fear the loss of the sneers and sarcasms that have been bestowed by this age on the schoolmen, for their abuse of the Organon of Aristotle. Like bread cast upon the waters they will return to us after many days. Ages to come will render them back with accumulated interest, to mark their sense of the treatment the Organum of Bacon has received in the house of those who style themselves *par excellence* its friends.

The immortality of the work itself is doubtless secure. As an exponent of the prevailing ideas on this subject, it will be handed down as a literary curiosity. It will be a standing monument of misspent ingenuity, and of the extreme absurdity to which the human mind can be carried by its *vis inertiæ*, when an impulse is once given to it in a wrong direction.

ESSAY II.

In the preceding essay the inadequacy of Bell's theory to account for the facts, which, to justify its pretensions, were incumbent on it to explain, I consider to be fully made out. Important errors and absurd consequences, into which ingenious minds have been led, such as it is inconceivable they could have fallen into, had they not followed a false light, have been exemplified as the legitimate fruits of his doctrine. It becomes me also to say, that the whole system has received a severe handling from Dr. Bennett Dowler, of New Orleans, whose writings on this subject, I had no opportunity of reading, before the publication of the foregoing in the Boston Medical and Surgical Journal, in 1854–5, but which, since then, he has been so kind as to forward to me. So far as the refutation of Bell is concerned, it seems unnecessary to add anything to what has already been said, either by him in advance, or by myself in the essay just closed. But when a theory, though false, has maintained its hold for a single generation, and fortified itself by such influences as we have seen surrounding the one in question, it becomes ingrained like a prejudice: and it will not quit its hold at the bidding of a first or a second refutation. I shall therefore pursue the subject by referring to some of the general probabilities against the fundamental idea of vital properties, and by showing that a correct application of the powers of mind to the physical properties of the nerves, is all that is requisite to explain the phenomena.

GENERAL PROBABILITIES AGAINST THE THEORY OF VITAL ENDOWMENTS.

One of the most obvious objections to this doctrine, and one which we meet with, on the very threshold, is its violation of all analogy, by the multiplication of secondary causes. The progress of science is marked by a diminution in the number of such causes, and a successive reference of the facts discovered, to principles more and more general. Here, however, the reverse obtains. Instead of generalization, we have particularization. Every new fact requires a new specific property to explain it. The different nerves and nervous centres have different endowments for the special offices which they perform; and the whole nervous system has its general endowments. To such an extent has this process reached, that if we allow a fibre or a centre for each endowment, there are not enough of either to supply the demand.

But it is not in the mere number of these endowments, that the greatest objection lies. They are occult causes.

While we are permitted to see no adaptation in these endowments to produce the effects attributed to them, we can perceive no adaptation in the organs to accommodate the endowments. While, also, the endowments resemble nothing else in nature, they have no discernible analogy with each other. So that, could we form a conception of the nature of one of them, it would not help us to conceive of the rest.

It was the opinion of the late Dr. Armstrong, that, from the action of arterial blood on nervous matter, some new principle would be discovered to spring up, a "tertium quid," which was neither exactly matter, nor yet mind; but a sort of common substance between the two, and out of which the phenomena of both matter and mind would be elicited. Had he lived to our day, he would have found his anticipations more than realized. In the assumption of vital properties of nerves, we have not only a tertium quid, but a quartum quid, a quintum quid, and so on until the whole vocabulary of Latin numerals is exhausted. But the misfortune is, that they rather diminish than add to our knowledge; for instead of explaining any thing they are inexplicable themselves. As this tertium quid is neither of the nature of mind, nor of matter, we have no faculty by which we can come into relation with it. Nor if we could, would that help us to conceive of the next. For the quartum quid differs as much from the tertium quid, as does this from the secundum quid. They are all nescio quids. Yet these strangers, to whom we are thus unable to get an introduction, are so generous as to impart to us all our feelings, and to perform for us all our motions. They think for us, remember for us, reason for us, liberate us from moral responsibility, and even fall in love for us. But there is one essential draw-back to the value of their services. Inasmuch as we are forbidden to enter into their secret councils, we can form no anticipation of the results of their deliberations in any given case. Any number of them may be supposed to be convened in the great State-house of the brain, but who can tell, from a knowledge of their characters, what their reflex operations on government, laws, science, religion, or morals will bring forth.

We see, therefore, that this theory sets out with violating, in both its essential elements, the great rule of philosophizing laid down by Newton with the concurrent approval of all philosophers, viz: "No more causes, nor any other causes of natural effects, ought to be admitted, but such as are both true, and are sufficient for explaining their appearances."*

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* It is difficult to conceive on what grounds, Sir Wm. Hamilton, condemns the expression, "such as are both true," in the foregoing sentence, as redundant; unless, he supposes, that any hypothesis whatever, if it simply explains the facts, is a legitimate one. For not only are the two principles perfectly distinct in themselves, but have each of them independently furnished the grounds, by which a theory, in one of the two most advanced of the physical sciences, has been rejected. The ancient theory of Cycles and Epicycles, served to explain the motions, and admitted of correct calculations as to the periodical times, and places of the heavenly bodies; it admitted none but known causes, but multiplied them to such an excess, that it became unwieldy, and as a consequence, fell before the simpler elliptical theory of Kepler. On the other hand, the hypothesis of the luminiferous ether, was simple and consistent, but it was not a 'vera causa.' And it has justly been condemned by Comte, and Mill.

A writer in the British and Foreign Medical Review, vol. xv., p. 139, in opposition to our distinguished countryman, Paine, argues in favor of these properties as follows: "First, as to the origin of these properties. We see these so inseparably connected with particular forms of structure,—the properties never being manifested without the structure, and the structure never existing in its perfect state without the properties,—that no reasonable ground can be assigned for attributing vital properties to anything else than that peculiar structural arrangement, and that peculiar union of elements which characterize the tissue exhibiting them. There is here a strong *analogy*, then, to the production of a new and peculiar set of properties in a piece of mechanism, or in a chemical compound, by a certain disposition of elements; but it is only an analogy, since the conditions requisite for the production of an organized tissue, are, as already shown, of a new and peculiar character. Still, the analogy is important in this,—that, as we do not consider it necessary to imagine the separate existence of an elastic principle which is imparted to steel, when tempered in a peculiar way, or of a saline principle, which is imparted to muriatic acid and soda, in the act of their combination,—so there is no necessity to infer the existence of a vital principle, because a tissue formed in a peculiar manner, possesses peculiar properties. *And upon the logical principle of avoiding unnecessary hypotheses, we cannot but do wrong in making such an assumption.* For we may consider it as a law of the Creator, equally constant in its operation with any of those already alluded to, that the act of organization, or the production of an organized structure out of an amorphus *plasma*, does generate, or develope certain properties, which are as closely related to the structure as elasticity is to blue tempered steel. If there be not such laws of uniform operation in physiology, we know not what hope there is of ever raising it in the scale of sciences."

This reasoning, in which the reviewer assures us, "some very able logicians have been unable to detect any flaw," does not reach the case. It will only apply to instances where but a single property springs out of a single definite structure, as, for example, contractility in the muscular fibre. Where a number of distinct properties, having no conceivable resemblance to one another, are attributed to the same organized structure, as the endowments of nerves, or the varied supposed properties of cells according to the different glands they enter into the composition of, or the different tissues they are metamorphosed into, it has no place. To escape from this dilemma, he imagines some infinitesimal variation of structure in the cell, far beyond the power of the microscope to reveal, or some change in composition, which chemical analysis cannot as yet define. But this is begging the question. The vital endowments of the nerves must be considered as superadded to their structure. Each one is a specific cause—a new creation. We have all the evidence that the nature of the case is susceptible of, that the structure is the same for all. No one in his senses will ever believe that this structure is so modified in the optic nerve, as to have the property of affecting the mind with color, and in the anterior column of the spinal marrow, so as to have the property of exciting muscular contraction. "The logical principle of avoiding unnecessary hypotheses," therefore, points in the opposite direction. We assume one of these properties for every new mental fact that we explain. Granting, then, that the vital principle is an assumption, it reduces the number of such assumptions from almost infinity to one.

The Reviewer sums up by saying "that, as there are certain properties of matter, which operate in a certain uniform manner, (or according to certain laws,) to produce the class of phenomena which we ordinarily designate as physical—and as there are certain other properties which act in their peculiar manner to produce chemical phenomena—so there is another class restricted to particular elements, which, when operating under certain required conditions, produce vital phenomena." To this it may be replied, that the logic is loose, and the analogy distant. It may be met and parodied by saying: That as the simple aggregations of matter possess both physical and chemical qualities, so, the binary compounds possess other physical and chemical qualities,—the ternary compounds, (or those of vegetable organizations,) still other physical and chemical qualities,—the quarternary compounds, (or those peculiar to animal organizations,) yet other, and higher physical and chemical qualities. And since we know that all these qualities actually exist, is it not more philosophical before we assume the existence of others, which we know nothing about, to enquire whether the act of organization is not to bring these last physical and chemical qualities into subserviency to the great purposes of man's existence in a world of material causes and laws? If we admit of the existence of a vital principle, or of a spiritual agent, which developes itself in the life of the body on the one hand, and in the life of the mind on the other, there is no occasion for predicating any thing else of the tissues but the new *chemical* and *mechanical* properties developed by the act of organization; and it is pertinent to say of these only, that they might exist in a latent state in the component elements. These only are "as closely related to the structures, as elasticity is to blue tempered steel." It is granted that "no chemical admixture of ingredients, nor any structural arrangement of them, could produce a tissue that would contract on the application of a stimulus." But there may be a chemical admixture and a mechanical arrangement, which adapt a structure for the application of this power. And this is all that really belongs to the muscle. The supposed properties of contractility and irritability are powers of the vital agent. The strong attraction of carbon and hydrogen for oxygen, it is natural to suppose, may have its influence in rendering the compound vegetable elements fixed in adhesion, so that they are comparatively immobile among themselves; while, the addition in animal structures of the fourth element, nitrogen, with its indifference for oxygen, and self repulsiveness, may serve to render them mobile, and the union of the antagonizing properties of cohesion, and repulsion, thus engendered, adapt the muscle to produce a mechanical effect when the power of contractility is applied. It is only thus, that we can discern a propriety in the expression of the reviewer, that the properties resulting from the act of organization are latent in the elements. When we would draw analogical conclusions from mechanical and chemical phenomena, we must keep, as it were, within the *forms* of chemical and mechanical laws. Nothing but confusion results when we step beyond these boundaries.

A sufficient reason can be given for the organization of all the tissues, by supposing its end to be, to develope mechanical qualities. We see, by this idea, not only the use of the chemical ingredients, but that of the arrangement of parts. Every organ and organic system in the body appears, on the surface of things, to be constructed as it is, solely for the purpose of attaining the physical results that grow out of that construction. It is by the hardness and firmness of bone, physical qualites, in which, too, we recognize the influence of its chief chemical ingredient, phosphate of lime, that it subserves all its varied purposes in the animal economy. Muscle is adapted, by its capability of being contracted while tense, to produce a mechanical effect. The strength and flexibility of tendons, the hydraulic powers of the vascular system, are all physical properties. The serous and synovial membranes possess the physical qualities of smoothness and polish, to enable the organs, which they cover, to glide over each other with the least possible amount of friction. The eye, and the ear, the heart, lungs and stomach, subserve their purposes by the physical qualities which they possess. Vital powers may be concerned in their formation, and vital processes may be carried on within them: but when they are formed, they favor these operations solely by the physical qualities that belong to their structure. There is therefore no analogy in the other organs and tissues for vital endowments of nerves. If such exist, they constitute an anomaly in the system. Analogy here, as well as of nature generally, concurs with the philosophical law which condemns the mutiplications of causes, and with that which forbids the introduction of *occult* causes, in pointing to the developement of physical powers and qualities merely, as the end of the organization of the nerves.

And this conclusion is confirmed by the structures and position of the several parts of the nervous system, both in relation to themselves, and to other organs; in which, is an evident adaptation to a physical office. Can any unprejudiced observer imagine for a moment, that nature took pains to build up the nervous fibres, arrange them into cords, expand them on surfaces to receive material impulses, isolate them to a certain extent, and then nullify her work, by bestowing on them endowments which bear no relation to these properties? Is there any meaning in this structure, if it is not for the purpose of receiving and transmitting impulses? Again, in the ganglion, centre of the spinal marrow, surface of the convolutions of the cerebrum and of the laminæ of the cerebellum, the same structure is thrown into three different forms, and each successive higher form is a better adaptation on physical principles, to perform one and the same office. Does not this fact almost force the conclusion, that this office is a single and a physical one?

The causes also, which act from without, through the organs of the senses on the nerves to excite their normal activity, there is reason to believe, all act according to the law of impulse. They are therefore calculated, as far as we can form a conception of their action, to excite nothing but mechanical agitations in the nerves themselves. So, likewise, the causes which, without destroying the structure, most strikingly interfere with nervous aclivities, are those which impede mechanical motions. Concussion and compression, which annihilate the functions of the brain for the time being, are evidently calculated to arrest vibrations, or other agitations of the nervous matter composing it. The same is true of the individual nerves. If a nerve be tied or otherwise compressed, its function beyond is arrested. This will not however arrest the passage of electricity beyond that part. A fact, which gives us reason to infer that the function so arrested is of a material nature, grosser even than electricity. What more probable, than that it is a motion among the particles composing the nervous cord? The crossing of the influence of the two hemispheres, as exemplified in palsy, the rotatory motions arising from the loss of the influence of one half of the cerebellum as in the experiments of Magendie, and the decussations of fibres in the optic nerves, and in the medulla spinalis, all take place according to the law of direction of a physical force generated in these centres, and surfaces, and mutually acting and reacting between them.

The organs of the senses are evidently constructed on the principle of bringing different classes of mechanical impulses into relation with the same physical properties of nervous tissue. Externally, they appear formed with reference to the condensation and concentration of these mechanical impulses, and internally, there is a concentration and insulation of nervous tissues to receive them. And it is worthy of remark, that the more refined and delicate the outward impulses, the greater the magnifying and intensifying power of the organ, and the greater the number of fibres, (as in the eye and ear,) on the same surface. Now this appears altogether a work of supererogation on the part of nature, if she makes specific sensation, to depend on a vital endowment of a nerve. For she could give that endowment to a few fibres, as easily as to many, and she could make a nerve so endowed, see or hear without an organ, as well as with one. This point will be considered more at length in another connexion. It is introduced here, to show that the common theory, contrary to the common belief, accuses nature of not being economical in her selection of means to an end.

REVIEW OF THE POSITIVE FACTS IN SUPPORT OF THE THEORY.

The foregoing are some of the a priori considerations, which readily suggest themselves, as favoring the idea of the single and material office of the nervous system, in its relation to the mind. Taken separately, they would not perhaps be regarded as entitled to much weight in a question of facts. But collectively, they afford a strong ground of presumption, which should lead us to question closely, conflicting facts, lest we be imposed on by *appearances* merely, in an investigation so complicated. In the whole range of physiological experiments, but two facts have been brought to light, on which much stress has been laid to *prove* the doctrine of vital endowments. One of these, is, the specific sensation arising in the mind when the nerve of special sense is irritated; the other, is the contraction of a muscle, when the nerve leading to it is separated from the centre and stimulated. From the former, it is inferred that there is a specific property in the nerve, which affects the mind with the sensation. From the latter, that there is a specific property of the nerve, which occasions the muscle to contract. In each case, the materialistic observer judges precisely as he would of a phenomenon purely physical. He can imagine no cause in operation, which is not evident to the senses. He perceives not the possibility of the mind intervening to affect itself with the sensation, because such an act, if it takes place, is beyond the depths of consciousness. He sees not again the possibility of the intervention of an act of the mind to effect the contraction of the muscle, because the nervous connexion between the muscle and the brain, which he considers the seat of the mind is interrupted.

Before however, we accept conclusions which violate all analogy—which ignore the connexion between structure and function—which explain phenomena by occult causes—which subvert mental philosophy—and which lead to consequences not only absurd, but mischievous—a full demonstration is required, that the inherence of such phenomena in the mind as cause, is impossible. And it is the business of those who urge these phenomena in favor of such conclusions, to make this demonstration good. The onus probandi lies with them. How far they have acquitted themselves of this task, may be seen by the following extract from Muller, in which the whole grounds of this theory, and, so far as sensation is concerned, the history of its rise is set forth.

"The nerves have always been regarded as conductors, through the medium of which we are made conscious of external impressions. Thus the nerves of the senses have been looked upon as mere passive conductors, through which the impressions made by the properties of bodies were supposed to be transmitted unchanged to the sensorium. More recently, physiologists have begun to analyze these opinions. If the nerves are mere passive conductors of the impressions of light, sonorous vibrations, and odors, how does it happen that the nerve which perceives odors is sensible to this kind of impressions only, and to no others, while by another nerve odors are not perceived; that the nerve which is sensible to the vibrations of light, or the luminous oscillations, is insensible to the sonorous vibrations," &c. * * * "These considerations have induced physiologists to ascribe to the individual nerves of the senses, a special sensibility to certain impressions, by which they are supposed to be conductors of certain qualities of bodies, and not of others.

"This last theory, of which, ten or twenty years since, no one doubted the correctness, on being subjected to a comparison with facts, was found unsatisfactory. For the same stimulus, for example, electricity may act simultaneously on all the organs of sense,—all are sensible to its action; but the nerve of each sense is affected in a different way,—becomes the seat of a different sensation: in one, the sensation of light is produced; in another, a sensation of sound; in a third, taste; while in a fourth, pain and a sensation of a shock is produced. Mechanical irritation excites in one nerve, a luminous spectrum; in another, a humming sound; in a third, pain. * * * * A consideration of such facts could not but lead to the inference, that the special susceptibility of nerves for certain impressions is not a satisfactory theory, and that the nerves of the sense are not mere passive conductors, but that each peculiar nerve of sense has special powers or qualities, which the existing causes rendered manifest."

In a question of this sort there are three classes of facts, which must be considered and disposed of, before the correct conclusion can be drawn. 1st—All those connected with the structure of the organs of the senses, including their nerves, and with the physical agents impressing them, which lead us to infer a mechanical effect as the result of their combined action. 2d—The sequences of the phenomena when the specific nerves are irritated. 3d—All those founded on the nature of the mind itself, as made known by consciousness, and which reveal sensibility in all its modifications as a faculty of the mind purely.

It is necessary that such an explanation should be given of sensation as will harmonize all of these three classes of facts. Any theory founded on one of them to the exclusion of the rest, must be partial and imperfect. If we accept even that doctrine of causation which rests the whole idea of cause on simple antecedence and consequence, and which relies for its authority solely on habitual experience, then the second of these classes of facts are of no more weight than either of the others. For habitual experience no more constantly assures us that the antecedent is the cause of the consequent, than it declares that mechanical powers and arrangements produce none but mechanical effects; or that mental effects spring from mental causes. Now, of the three theories of sensation referred to, in the last paragraph of the quotation from Muller, the latest, and the one now generally adopted, was founded wholly on the consideration of the second class of facts. The other two classes, which formed the chief ground-work of the first of the theories alluded to, or that of the nerves being passive conductors, being in collision with the conclusions drawn, are thrown completely out of the discussion. If, therefore, no way could be readily seen, by which these facts could be reconciled, still, true philosophy would hesitate before it adopted so partial a view. It would naturally suspect some flaw in the reasoning, or that some important fact had been overlooked in a question so complicated.

The cause of the discrepancy, however, does not lie so deep as to be beyond the reach of the most superficial mind. It consists, simply, as aforesaid, in the fact, that in a mixed problem, where material and immaterial causes meet, the former are more obtrusive, being sensible, and are alone regarded. And that, as a consequence, the occasional are mistaken for the efficient causes.

It will readily be granted, by all who are alive to the almost infinite rapidity of the action of the mind, especially in cases where it is habituated to act in a given manner, that, though, when a specific nerve is irritated, the sensation *appears* to rise in the mind instantaneously, there is yet time for an act of the mind to intervene between the impression and the sensation experienced. It will also be admitted, that, according to the principle of association, if the mind is frequently experiencing a given sensation, in connection with the physical agitation of a nerve, which, also, it feels, it would call up that sensation, on the recurrence of this agitation, even though it is produced by a different stimulus. The sensation, being normally excited in the first instance, corresponds to the realities of things; in the second, it is illusory.

Here, then, is the true solution of the mystery. By the law of the union of the mind with the body—by the law which unites its cognitive power with external objects, through physical impressions on nerves, it cannot but act, when the nerve is stimulated; and it acts in the way it has been in the habit of acting when the nerve is—*normally* stimulated: consequently, the sensation experienced resembles the true sensation of the part. These sensations are to be considered in the light of hallucinations, or sensual illusions. They are deceptive appearances,* and instead of explaining the real, are *themselves* to be explained *by the real.* It is because that originally, and habitually, the nerves are physically agitated in connection with the mind's experiencing the *true* and *real* sensation, that by the law of association, it repeats this sensation when they are agitated by a stimulus of a different kind. The doctrine now maintained, is an exact reversal of the truth. It is like saying, the sun moves round the earth, whereas the earth is the moving body. It associates the sensations with the organic affections, whereas the organic affections have been associated with the sensations. It makes the mind passive in sensation—merely perceiving these affections of the nerves, whereas, it is active, perceiving external things. It, moreover, takes away all ground for a belief in an external world, inasmuch as it limits our knowledge in sensation to these subjective affections, while it is the belief of mankind that it extends to things as they are in themselves.

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* Deceptive in sensation, it is remarkable that they should extend their power of deception into the province of reason, by imposing a false theory on mankind for years.

But the process of sensation which we have just indicated, while it evolves these illusory appearances according to known mental laws, suggests an office for the organs and the specific nerves, which is in harmony with their structure and relations, and thus brings in one colligation all of the three classes of facts above referred to. Notwithstanding there is a strong persuasion generally prevalent, that there is a something in the organ which affects the mind and produces the sensation, there is good reason to believe that this is little better than a prejudice. And it probably owes its origin in a great measure, to the fact of an image being reflected from the retina. While, however, such an instance, confined to the retina alone of the special organs, being also the common effect of light reflected from a focal distance, may be readily conceived to be the *incidental* effect of the reciprocal action of this substance and the surface, it is difficult to rid ourselves of the idea, that if the image is what we perceive, we should see it in the inverted position, and double.

It is doubtful whether a thorough and profound analysis of sensation would assign a more important office to the organ, than merely to arrest and fix the attention of the mind on the object. In perception, and in all the other acts of the mind, we are conscious of a concentration of attention as the essential prerequisite to the healthy performance of whatever it may, for the time, be engaged in. There is no resemblance, and we can conceive of no necessary connection between the external impression and the sensation felt. In perception, the mind attends and constructs the object in space. In reasoning, it attends and recognizes intuitive judgments. In sensation, the last fact that external observation reveals to us, is a physical agitation of a nerve; and the first fact that internal observation reveals, is an act of attention. Is it not, therefore, as good philosophy to say that the mind, roused by this physical disturbance, has its attention directed to the cause, and experiences the sensation by its own innate powers, as to say that the physical impression leaves the sensation on the nerve, to be subsequently transferred to the mind as to a passive recipient? May it not thus intuite external truths, as well as internal?

Examples might be adduced, from all the senses, where illusions of perception, which analogy, if not the identity of perception and sensation, lead us to refer to the same fundamental law as those illusions above mentioned, occur, without any possibility of their dependence on properties of nerves. A single one, however, will suffice for illustration. The familiar instance of the false sensations witnessed in a case of amputation of a limb. It is well known that the subject of such an operation, experiences all the usual feelings of the limb in its integrity. But what is in point for our present purpose, is, that he not only has the same feelings which are common to others, but he has some peculiar to himself. If he has been accustomed to feel a particular pain, for instance, before amputation, he will feel the same afterwards. If he has been in the habit of wearing a tight boot or garter, he will occasionally feel either of them on, while his leg is off. Now it is not supposable that he has any different nerve endowments from others. Nor is it supposable that those feelings, which he has in common with others, are produced in a different way from those peculiar to himself. If one class are produced by vital endowments of nerves, so are the other. On the contrary, if one class are owing to the reaction of the mind on the physical agitations of nerves, so are the other. These facts are all deducible from the known powers of the mind, according to the principle of association; and render the introduction of the hypothesis of vital properties unnecessary. They are the simple aberrations of the mind's activity,—the indirect consequences of its cognitive power being associated with external physical impressions.

It may, however, be objected to the doctrine of these false sensations and perceptions being the result of the mind's associating with the physical excitement of the nerves, the sensations felt through the normal and habitual excitement of them, that these facts are congenital, and might be witnessed, (had the child the power of expressing its feelings,) at the moment of birth, and consequently before it had had time to form such associations. This objection would be entitled to some weight were the mind a perfect blank, as Locke thought, on its entrance into this world. In the phenomena of instinct we have abundant examples of associations, which must have been formed previous to the birth of the individual in which they are manifested, and which must be considered entirely independent of nervous properties, for sometimes there is no room to suppose any addition to the nervous system to account for a new association. The pointer, setter, and shepherd dogs act as their progenitors acted, on the first occasion of their exercising their peculiar instincts. But has any one ever discovered, or thought of discovering a new ganglion to distinguish them from other dogs, or from each other? The young foal neighs, kicks, and rolls, precisely as his ancestors did, on the day of his birth, and before he has received any instruction from his elders. The child sucks his thumb a minute after he is born, as soon as he is capable of experiencing a sensation of light when the retina is irritated. In each case, he feels a sensation proximate to the true one, and acts accordingly. But if we should hence say, that he experiences the true sensation on the same ground that he experiences the false one, we should be guilty of saying, that the child nurses the breast because he sucks his thumb.*

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* In the recent work of Professor Bowen, of Harvard College, on Metaphysics and Ethics, at page 228 of the second edition, the author, after admitting that such motions as the beating of the heart, the movements of respiration, and the peristaltic actions of the intestines, are properly automatic, or mechanical, qualifies his admission in a note, as follows:

"To avoid misconception, I may here mention, once for all, that I use the common phraseology that is founded on the mechanical theory of nature's operations, or the doctrine of secondary causes, but without admitting the truth of that theory. In the former part, I endeavered to prove that all action or change in the purely material creation, must be attributed to the immediate agency of the creator. Still, for the convenience of speech, to avoid circumvolution and incessant reference to this doctrine, I continue to use the language that is sanctioned by universal custom, though it is derived from what seems to me a wholly unphilosophical and mistaken view."

With this ingenious author, whom it is a pleasure at all times to read, I agree in this use of language, so far as it is adopted in reference to inorganic substances. It is allowable here, on a somewhat similar principle as the license adopted by mathematicians in the popular mode of squaring the circle. When a polygon is inscribed or circumscribed about a circle, it differs so little from its area that the amount of that difference may safely be thrown away for common practical purposes. But just in proportion as you lessen the number of sides, this difference

The idea of original association as the cause of these phenomena, receives further confirmation from the fact, that persons born with defective limbs experience sensations similar to those felt by the subjects of amputation. (Muller.)

But we need not go beyond the limits of vision, to find a demonstration that irritation of the specific nerves in a new born infant, affords no proof of their vital endowments. It is admitted that objects are seen erect, with an inverted image on the retina, originally ; and their magnitudes, forms, and distances are estimated by some of the lower animals, if not by man, as accurately at birth. as at any subsequent time. Yet no one ever imagined a vital endowment of a nerve, to give it the faculty of seeing upside down, or (if the phrenologists are excepted,) others to enable the mind to judge of size, form, or distance. Yet it is manifest, that whatever will account for either one of these, will also account for a sensation of light, the first time that the optic nerve is irritated.

Enough has been said to prove that the opinion of specific sensation being dependent on vital endowments of nerves, has been too hastily adopted. The facts adduced by Muller, of false sensations arising in the mind, when the specific nerves are irritated, are explicable on the principle of association, while the conclusion which he draws from them is contradicted by two other classes of facts of equal authority ; one of which assigns a physical function to the nerves, and the other confirms sensibility in all its departments to be a purely mental faculty. The theory therefore falls to the ground, and it is really unnecessary to pursue the argument farther ; a few other considerations, however, may be added to what has been said, which will place the subject in a clearer light.

If these specific sensibilities are the result of specific properties of nerves, it might be enquired, how happens it that there is no gustatory nerve ? No nerve has as yet been discovered, whose trunk, when irritated, produces a feeling of taste in the mind, and yet sweetness and sourness are as much specific sensations as redness and greenness. So are heat and cold as specific, as rough and smooth ;

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rises in importance. So when you undertake to apply such terms to the motions of animals, the reaction of the language leads into grave errors. The mind, always aiming to assimilate the new facts with what was previously known, is instinctively led to conceive of them under the relation of mechanical causes and laws. The mere loss of consciousness of volition, on the part of the animal, or of the sensations on which the movements are based, is not of so much importance as whether they are to be referred to mechanical or mental laws and causes. Are habits no longer regulated by mental laws, when they cease to be attended with consciousness ? If they are not, when did they pass out of one province into the other ? When habits become hereditary instincts, do they then revolutionize their form of government ? If they do, what historian has chronicled the change ?

Investigations may be carried on, and knowledge acquired in the purely physical sciences, without necessarily keeping in sight the efficient causes ; but in studying vital phenomena, efficient causes are not to be blinked out of view, not even with a protest. The polygon here becomes a square. These phenomena cannot be arranged, and classified, and discoursed about intelligibly, without a constant reference to those causes and the laws which limit them. Hence, in quoting with approbation and adopting the terms of Carpenter and his school, the Professor has rendered his chapter on the " Nature of Instinct," the most unsatisfactory portion of his whole book. If he would take the trouble of reading the chapter on the functions of the Cerebrum in Carpenter, and see what use he there makes of the reflex function, he would, perhaps, find reason to withdraw his endorsement of this theory. Formerly, metaphysicians opposed a barrier to the materializing tendencies of physiologists ; but, of late, it seems that they have made an unconditional surrender.

yet, what nerve, going to the skin, imparts either of these sensations when irritated? Again: some of these feelings can be imitated, if impressions, purely physical, are made on the expanded extremities of the nerves, while, if they are made on the *trunks*, no such effects follow. A sense of nausea arises if the fauces be irritated; an acid or saline taste, if the tip of the tongue be struck gently. Here, we see that the nearer we approach the physiological process, the nearer we are to the physiological result. A converse demonstration is the fact, that through the nerves of the eye and ear, the irritation of whose trunks invariably produces those specific sensations, none other than sensations of sight and sound are ever normally transmitted. Here, then, also, we should naturally infer, that the more habituated the mind is to receive specific sensations, through certain nerves, the more certainly does the physical excitation of the trunk give rise to the corresponding false sensation. Such facts admit of explanation only on the theory of the mind's associating the sensations with the nerves. To be consistent, the theory of vital properties requires, that irritation of their trunks should excite them, as well as irritation of their extremities; and that one nerve should as truly and completely exhibit this property, as another.

It also requires, that every distinct class of sensation should have its appropriate nerves, and that every nerve should have its appropriate property, while neither of these facts can be possitively asserted of any class of sensations, or of any nerve, where the nerve is not insulated by its organ from all but one class of impressions. Some philosophers of this school, have, indeed, imagined the existence of distinct fibres for the evidently distinct classes of sensations, which are experienced through the general nerves; but they have been philosophers, rather than physiologists. Having received this doctrine from the hands of physiologists, and recognising in consciousness, sensations of touch, of temperature, of disorganization, muscular sensations, &c., at least as many kinds as are included under the term specific, they have naturally expected the same provision for the one as the other. But the absurdity of this idea, when the size of the nerves is considered, has induced even those physiologists, who otherwise agree with them, to discard it altogether.

The absence of a distinct dividing line between the nerves of general and specific sensations, which is manifested by the sensations of taste being communicated to the mind through the medium of, at least, two nerves of common sensation, is still farther confirmed when we look for the specific nerves of the invertebrata. Although there can be no doubt of the sensibility of insects to sounds and odors, naturalists have hitherto failed in assigning to any distinct nerve either of these functions. Indeed, their ideas of specific properties have been a bar to their ascertaining the respective organs of these senses. Amid conflicting statements, however, there seems good reason to suppose that the antennal nerves are employed in smell and hearing, as well as in touch, not only with insects but with the crustacea.* Thus, while specific sensations are dependent on specific properties of nerves, we find, in man, four classes of these sensations with three nerves; and in the highest of the invertebrata, the same number of the former, with but one of the latter, viz: the optic, which alone can be recognized as answering the conditions requisite to constitute it a specific nerve.

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* If we consider this fact, along with the experiments of Magendie, which tend to show that the sense of smell in dogs is not dependent on the olfactory nerve alone, and with the observations of Beclard and Mercy, of cancerous induration of the olfactory lobes and nerves, with persistence of the power of smell, in man, we have three concurrent proofs from different sources,—viz: the different stages of its progress,—that the apparent specialization of the nerves of the senses is the result of association. For, in the lowest animals, it has not proceed-

When we interrogate consciousness, we recognize the power that perceives and distinguishes one color from another, as precisely the same as the power which distinguishes a color from a sound. That power which distinguishes a color from a sound, is precisely the same as that which distinguishes a sound from a smell. The power which distinguishes a sound from a smell, is the same as that which discriminates one thought from another, or a thought from a feeling, or a feeling from a volition. Now, if we distinguish color from sound by a property of nerve, we have need of similar properties of nerves by which to distinguish different colors from each other; and if so, other properties, by which to distinguish shades of colors. And so with sounds, odors, tastes, tactile sensations, thoughts, feelings, volitions. The absurdity to which we have already alluded, when speaking of special fibres for the distinct classes of general sensations, renews itself here in a redoubled form. For the fibres of nerves, however numerous they may be supposed to be, must have a final limitation, while no limit can be assigned to the number of sensations, thoughts, &c., we are capable of experiencing. If, therefore, we undertake to assign a fibre, with its specific endowment, to every sensation, thought, feeling, and volition, in the end, we shall find our stock of fibres exhausted, while yet an unlimited residue of mental affections remains.

It must be accounted a little remarkable, if, after having convicted this theory of a discrepancy between the number of fibres actually existing, and the number necessary to allow a fibre for each endowment, we should be able to point out a further discrepancy between the *size* of the fibres, and that which they should have, to fulfill the requisite conditions. Yet, microscopical admeasurement of the papillæ that form the surface of the retina, has developed a fact, which seems altogether inconsistent with the idea of sensations of sight being dependent on vital endowments of its individual fibres, and one, the obvious bearing of which has not escaped the attention of philosophers of this school. A fibre, according to this doctrine, runs isolated from circumference to centre, and (in the optic,) should give a sensation locally distinct from all others. A papilla of the retina is supposed to be the terminal head of the fibre. Now a papilla is many times larger than the 'minimum visibile.' A hundred different colored objects, (more or less,) may therefore impinge on a single papilla, and the question is, which one will be returned to the mind as a sensation? When we compare this fact, with that of single vision, with two eyes, and with that of erect vision with an inverted image, we shall find renewed evidence that the part which the organ plays in seeing, compared with that which the mind takes, is of small moment.

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ed so far as to enable us to distinguish the special nerves or organs. In those of a higher degree, it has not as yet become completely disassociated from the common sensitive nerve of the face. While in the highest, we see it driven, as it were, from its strong hold, by the invasion of disease, retrograding on the line along which it originally progressed, and rallying on the next point d' appui; a mode of operation of the "vis medicatrix natura," of which abundant examples might be adduced. These facts, while they declare a *generality* of uniformity in the phenomena, such as would naturally spring from the associating process, with its results preserved by instinct, exhibit a want of that universitality, of it, which belongs to inherent properties.

A degree of internal evidence is afforded by the structure and development of the organs of the senses, and their relations to the nerves on the one hand, and to external agents on the other, that they are successive adaptations to the physical laws of those agents, and intended to bring them into relation with the same physical property of nerve. If we compare the organ of taste with that of touch, we observe as the only difference, a denudation of the nerves in the former organ, just sufficient to enable substances held in solution, to penetrate to them. We can therefore readily conceive of such substances agitating the nerves, and fixing the attention of the mind on the qualities from which these agitations originate, without any necessity for any new property of the nerve. A little farther denudation of the nerve, and perhaps a greater isolation from disturbing agents, would enable the same nerve to be thrown into agitation by bodies floating in the atmosphere. Here, again, the mind would attend, and, in knowing the causes of these agitations, experience smell. The same property, which, under the conditions of touch, could only respond to the grosser impressions of bodies, is thus brought into relation with the more refined impulses of smell and taste. But if all has been done that can be done, by denudation of the nerve, to bring it into relation with the feeble impressions of external objects, and it is requisite to excite agitations within it, by feebler impressions still, the next step would be the construction of an organ which shall magnify and intensify the impressions themselves. It is, hence, that occasion is given for the construction of the ear and eye. They are magnifiers and intensifiers of undulations, which, falling on the nerves of touch, would be incapable of throwing them into agitation, but which, by this means, are brought into relation with the same property.

In general, it may be said, that the organs of the specific senses are successive removes from that of touch, on the principle of bringing successively weaker and weaker physical impressions into relation with the same physical property. This is confirmed, not only by the structure of the organs themselves, but by the greater distances from which the sensitive impressions come, the more remote the organ from that of touch.

The disposition of the nerves in the organs of smell and taste, is, as they would naturally arrange themselves, were they originally of the same function, and the mind had gradually associated its powers of taste and smell with them. Thus, taste being experienced in connexion with bodies in a state of solution, the fluid medium, as the most obtrusive, first calls touch into exercise; the mind would therefore associate touch with the nerves which first receive these impulses, viz: those of the tip of the tongue. Subsequently, as touch palls, it would fix its attention on other impressions which are strong enough to disturb the physical status of the same nerve, and hence the nerves of taste would be more withdrawn towards the back part of the tongue and mouth, as we find them.

In the organ of smell, the mind would naturally employ its faculty of touch, in connexion with the agitations of those nerves which are more exposed to the impulses of the air, for they would first elicit attention, and would mask, as it were, the others. And it would engage its faculty of smell with those, which, being a little removed from the direct current, allow themselves to be agitated by feebler impulses, which in turn excite attention. By the continued repetition of these exercises, these faculties become associated with those nervous extremities, which, from their position, favor them respectively. Hence, it is, that the upper portions of the nostrils are occupied by the nerve of smell chiefly, while the nerve of touch is distributed mostly on their lower thirds. The absence of a gustatory nerve, exhibits, in man, the sense of taste as the transition state between general and special sensation: While in the invertebrata, the absence of an olfactory, or auditory, distinct in its origin and termination, shows, likewise, that the senses to which they belong, are in the same condition.

In like manner, as the illusory specific sensations, arising from irritating the trunks of certain nerves, are held to prove that those nerves have specific sensible endowments, so, the muscular contractions which arise, when certain other nerves are irritated, are held to prove that these nerves have motor endowments.

That this inference, like the last, has arisen from overlooking the insensible facts of the case, and that there can be no such motor power either in the nerve itself, or in the centre with which it is connected, I shall endeavor to show, by adducing facts, which prove,

1st. A variation in the results witnessed, according as the exact physiological process is imitated, or as a muscle is habitually contracted through the intervention of a nerve.

2d. By pointing out some of the absurd consequences involved in the supposition of our voluntary motions being caused by impulses, or other influences, generated in the brain and transmitted through the nerves to the muscles.

3d. By proving that all muscular contraction springs directly from mental action. And that the facts witnessed, are deducible, according to acknowledged mental laws, from the mind's activity, associated with external impressions on nerves. They, being, in short, facts of precisely the same character as those which have been just examined.

1st. It was noticed that the nerves of sensation were less likely to give rise to their specific sensations when their trunks were irritated, than when the surfaces, on which their extremities were spread out, are slightly stimulated. The same is true of the nerves of motion. No mode of irritating their trunks will occasion reflex motions so surely and perfectly, as impressions made on parts to which they are distributed. Here, then, also, we must make an approach to the physiological process, to develope the physiological result.

In the mixed nerves, so called, there is good reason to suppose that erroneous conclusions have been drawn, by this inconstancy of the irritation of the trunks to produce contractions, even when important motions are performed through them. The interminable disputes in regard to the functions of the par vagum, glosso-pharyngeal, superior-laryngeal, and other nerves, have been owing, in a great measure, to the oversight of this fact, and the expectation that irritations would as readily exhibit the functions of a nerve, when several are associated with it, as when there is but one. An expectation reasonable enough, if the function springs from an endowment, but vain, if from association.

As, also, we found that the nerves of those senses which were insulated by their organs from all impressions but the specific, were the only ones which invariably reproduced the specific sensations when irritated, so, now, we find that irritations of the anterior cords of the spinal nerves are alone invariably followed by contractions. And they are the only nerves whose functional activity, on the supposition, is coexistent *always* with muscular motion. With regard to the posterior, some affirm, others deny that they can be excited. There can be no doubt, however, that they are instrumental in the performance of motions, and in the experiencing of sensations as we have before shown.

It has been found so difficult to excite these muscular contractions in the alimentary canal, by stimulating the sympathetic nerve, that some physiologists have denied that it could be done at all. In this instance, the muscular coat, though occasionally contracted under the influence of the sympathetic, is *habitually* contracted by direct stimuli.

Here, then, are four concurrent sources of proof, that the power, which acts in connection with the nerve in contracting muscles, is an associated one, instead of a fixed endowment. For, in each case, the power varies according to habit. It varies in the individual nerve, according to the part to which the cause is habitually applied,—in different nerves, according as they are *wholly* or *partially* employed in contraction—and even with regard to the muscles, as they are *habitually* contracted through nerves or by direct impressions. Whereas, were it a motor power inherent in the nerve, irritation of the trunks should contract them as well as irritation of the extremities. One nerve possessing this power, should contract the muscles with which it is connected, as well as another, and all muscles should be contracted equally by the nerves terminating in them.

The last instance referred to, affords in another point of view, one of the strongest objections to the doctrine in question, that can be conceived of. There can be no doubt that the peristaltic contractions of the alimentary canal, and of the heart, take place by the influence of direct impressions. If we admit a motor power in nerves to produce the voluntary contractions of muscles, then we introduce two causes in operation in the human body to account for the same effect, viz: muscular contraction. A proceeding so unwarrantable as, in the opinion of eminent logicians, to justify, at once, the rejection of the hypothesis that entertains it, in favor of one that has but a single cause.

But we are not limited to these peristaltic contractions, nor even to the contractions of individual muscles, when separated from nervous influence, to prove the independence of contraction on the nerves. It has been ascertained by Dr. Bennet Dowler, of New Orleans, and by M. Brown Sequard, that, under peculiar circumstances, rhythmical and combined movements of the *voluntary* muscles take place in parts completely insulated from the nerves. These motions have been referred, by Carpenter and others, to the vis insita of Haller, or the contractility of the muscles themselves. But this power, while it will account for the contractions of the single muscles, cannot explain the combined action of several, necessary to produce a given motion. It cannot pass over from one muscle to another, and unite them in harmonious concert. A transcendental power is evidently in operation here, in which the bond of union lies. And if so, have we not good reason to infer that the same transcendental power cannot be absent, but must be in operation, where the nervous connexions still exist; and that the apparent nervous influence is a deceptive appearance altogether, founded on the associations of the activity of the one with the other?

It is also natural to suppose, that if the power by which a muscle is thrown into contraction, is in any way derivable from a nervous centre, we should find some correspondence between the size of that centre, and the degree of force with which the muscles connected with it, habitually, or occasionally, contract. No such connexion, however, can be traced between them. The size of the great centres, appears rather to bear a relation to the number of the nerves, and minor centres, with which they are connected, and whose actions they seem to control.

Among the lower animals, the serpent tribe for example, the muscular contractions are extremely forcible, often crushing the bones of the most powerful beasts of prey. The salmon has been said to leap to the height of fourteen feet perpendicularly, to overcome the obstacles in his way, while ascending rivers for the purpose of spawning. We cannot conceive of such motor power coming from the brain, or spinal marrow of these animals, on any principle we are cognizant of. Cramps of individual muscles, and the spasms of tetanus, which take place by virtue of the connection of the muscles with the seat of morbid irritation through the spinal cord, are many fold stronger than any voluntary contractions which we can make. Is, therefore, the spinal cord a greater generator of nervous power than the brain? The ganglionic centre of the respiratory motions is extremely small. Could we conceive that it was capable of furnishing the steam for the ordinary movement of respiration, we should still be at a loss to imagine where the supply would be found, for the sudden and extra calls of coughing, and sneezing.

Although there can be no relation between the force with which muscles contract, and the generating power of the respective centres, there can be no doubt that some relation exists between the size of these centres and the office they perform, in the minds of the advocates of vital endowments. It is therefore with a strange inconsistency, that they overlook this consideration altogether, when they assign the most complicated motions in the higher animals, to parts which have rather dwindled than increased from the conditions in which they existed in the lower animals, and were instrumental in them in the performance of the simplest movements. It is in this way that Dr. Carpenter arrives at his strongest argument in favor of the cerebrum being the organ of the intellectual faculties. Having attributed to the cerebellum the task of co-ordinating and combining the muscular movements in general, and to the sensory ganglia the task of performing all the movements which take place under the direction of the senses, including touch, and those which are the result of the mind's determination, he infers, that there is nothing *left* for the brain to do, but to think. The "nervous power" for the infinitely varied motions of the hand of man, on which all the arts of life depend, and of his organs of voice, and, in fact, for all that has been superadded to the simple wavelike motions of the fish, springs from three or four ganglia, relatively not larger than they are found in the lowest of this class. To this inconsistency, he is forced, by the doctrine that every organ must have its endowment, and that that endowment must remain the same in all the gradations of animals. A conclusion which, for its absurd disregard of the most prominent facts, can only be paralleled by another, which the same author draws, from what may be regarded as a corollary from the same doctrine. It is not only necessary that every organ should have its endowment, but that every endowment should have its organ. Having, by the above method of exclusion, discovered that the cerebrum has no endowment, unless that of intelligence is accorded to it, he next reverses the process, and finds that none of the invertebrata possess intelligence, because they have no brain. By a parity of reasoning, having attributed, in common with the phrenologists, the sexual instinct to the cerebellum, he denies this feeling to all animals of this class, because this organ also is not found in them. It is need-less to say that a theory, which deprives half of the living world of that which makes the beginning of their existence possible, and of that without which, the continuation of their existence for a day is impossible, is hardly worthy of a serious refutation.

The manner in which muscles are made to contract, to produce combined motion, is such as to utterly preclude the idea that they receive their stimulus through the nerves and the brain. The frequent changes in the force and rapidity of contraction, the sudden alternation of contraction and relaxation in a number of muscles, within a given time, can only be accounted for by the immediate presence of the mind to the muscles, and its direct and active superintendence of their motions. Witness the performances of the rope dancer, the wrestler, the pugilist, or the expert swordsman following the movements of his antagonist so closely that he almost seems to anticipate them. Can any one for a moment suppose that the Psyche of either of these athletes generates little messengers in the brain, and, as a boy fits his paper messengers to the string of his kite, affixes them to the nervous fibres, and thus dispatches them to the several muscles, to tell each one of them when, with how much force, and with how much velocity to contract, when to relax, how quick, and how far, when, perhaps, a score or more of these muscles are active in accomplishing a motion, required to be done in less than the two hundreth part of a second? Or is it more philosophical to imagine the Archeus of Van Helmont, sitting enthroned in his snug little office of the pineal gland, and telegraphing through the nervous wires, to the muscles of articulation, after being himself telegraphed by them of their exact condition, receiving and transmitting the messages with such rapidity, as to make them pronounce sixteen hundred letters in a minute?

We look in vain among the operations of mechanical causes, or among the dynamics of chemistry, electricity, light, heat, or any known physical power, for an analogy to such rapidity, not merely of motion, but of adaptation.* It is in mental action that the true analogy lies. The power which associates our muscles, is like none other than the power which associates our thoughts. The power which retains them in regular combinations is like none other than that which calls up our thoughts in separate trains. The power of the wrestler, or fencer, to vary and adapt his movements with such rapidity, depends on the intimate presence to his mind of the muscles, individually and collectively. It is precisely like that of the orator, who, on the spur of the moment, passes in review spontaneous trains of thought, singles out those that relate to his purpose, selects the words to clothe them in, arranges them grammatically and rhetorically, and enunciates them in a breath. There is the same consciousness of nisus or effort, when a new combination of muscular contractions has to be made, as when a new arrangement of thoughts has to be impressed on the memory. When we begin to learn to dance, or to play on a musical instrument, we dissever the muscles from their old combinations and recombine them, as in a work of imagination, we dissever thoughts from their old associations and form them into new ones. By the aid of memory we again call up these thoughts in the same train, and again contract these muscles in the same order and combination. And the oftener we do this, in each case, the less difficult the succession of both thoughts and muscular contractions becomes, until, in a continually diminishing consciousness of effort, they appear to take place spontaneously. In fact, we have the same reason to regard the muscles as present to the mind, as we have to regard the thoughts present to it. We recognise its principal faculties, memory, judgment, association, in operation in movements, and we recognise them operating where an intervening medium is inconceivable. This analogy extends even to paralysis. When in consequence of disease, or section of a nerve, a class of muscles is separated from the rest, the want of power in the mind to contract them in harmony with those from which they are dissevered, is like its inability to call up a particular train of thought. There are no means of suggesting them to the mind, held in its activity by the remaining muscles through their nerves.

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* The author of "Vestiges of Creation," reasoning from light, electricity, &c., estimates the velocity of mental action at 192,000 miles a second. Since he has condescended to give us one of the physical characteristics of mind, may we not reasonably expect more from his able pen? Will he not tell us about the size, and figure of mental action?—what is its weight, momentum, &c.? Or, since he is so expert in establishing his premises in one department of nature, and drawing his conclusions in another, cannot he give the solution of some of those perplexing problems with which the ingenuity of the youthful mind is often exercised to no purpose, such as "if a bushel of wheat costs a dollar, what will a yard of broadcloth amount to?"

The final confirmation of the conclusion which these facts force upon us, is derived from our consciousness that a volition, accompanied with a nisus or effort, is the immediate antecedent of the contraction of the muscles in our ordinary movements. This nisus or effort, which is regarded as the mind energizing, we are therefore constrained to look upon as the true cause of the motion. And no intervening medium, except the contractions of the muscles, seems called for.

If now, we take an example of the simplest form of motion known in connection with muscle and nerve, that, for instance, which takes place in a single segment of the lowest invertebrated animal, and follow out the natural interpretation, by explaining the physical facts according to the laws of physics, and the mental facts by the laws of mind, we shall find them fully adequate to account for the whole process, without any resort to occult causes. When a physical impression of a tactile order is made on the surface of such a segment or member, provided that surface is connected by nerve with the muscles that move it, a motion follows. What then is the character of that motion? Is it compounded on any principle of mechanics, of the forces which produced the physical impression? Or can it be conceived of as the result of any chemical, or other known force, generated in the ganglion, and transmitted to the muscles? All that we see and know to be necessary, is the nerve connexion. Nothing can be traced passing up to the ganglion—no product of the ganglion passing down to the muscles. We may, indeed, *infer*, from the known tendency of the impressing cause to produce physical agitation, and from the known adaptation of the structure of the nerve to transmit such agitations, that the external impulses have been as it were, continued on to the muscles. But here, sensible observation, and inference from sensible observation, ceases for a time. When it reappears, it informs us that muscular contraction has taken place, followed by a movement which partakes not of the character of physical necessity, but one which is optional, which springs from a motive; one of adaptation, of design; one, in which the elements of sensibility, intellect, and will, are plainly cognizable. The member is withdrawn if the impression is calculated to give rise to a painful sensation; it

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is protruded, as if to grasp, if it comes from an object of desire. Every one witnessing it, instinctively says, that the animal feels, and moves accordingly; and yet not altogether instinctively, for he reasons from himself. He is conscious that when he has made such a motion, after such an impression, he has always had an intervening sensation and volition.

In the light of consciousness, he recognizes this sensation as the remote incentive and guide, and the volition as the immediate cause. Observation reveals the contractions of the muscles as the intermediate physical steps in accomplishing the motion. And inference from this, and mental phenomena, discloses the associative principle and judgment, employed in combining and regulating the muscular contractions to produce the given effect; and no other intervening facts, is there a shadow of reason for believing, can ever be proved to exist between the volition and the motion. He transfers this reasoning to the animal; and under the influence of the philosophical principle, that like effects spring from like causes, he concludes that the simplest adapted motion of the lowest mollusk is through the same mechanism.

The absence of consciousness of sensation, or of volition, when a motion of adaptation takes place in a part separated from the great nervous centres, is no disproof of the conclusion at which we have thus arrived. When the mind is conscious of a sensation, it accomplishes a double act; or, as perhaps it may be better expressed, there are two phases to its activity—one looking towards the object, the other looking towards the subject: by the one, it recognises the feeling; by the other, it recognises itself in the act of feeling, affixes the feeling to itself, and thus is enabled to remember it. So, when it is conscious of a volition, it determines towards the object to be accomplished, and it recognises itself in that determination and thus remembers its volitions. In each case, the mind may perform the first of these operations and omit the second. In such an event, the operations are performed with much more rapidity, but are not recollected. Those philosophers who assert that the act of the mind for the moment, is the consciousness of the moment, do not express the whole truth. They confound the witness of the act, with the act itself. And we have abundant evidence that the mind, as in the formation of habits, where motions, at first difficult, become easily and quickly accomplished, accustoms itself frequently to go through the first part of the operation, without stopping for the second.

Consciousness must therefore be regarded, not as the power which experiences the sensation, or effects the motion, but the witness of the act of the mind which is the immediate antecedent. It is a witness which, though its testimony is direct and conclusive when it can be obtained, can only be brought to the stand to testify, in the integrity of the highest animal developement; and not even then in all cases. When, therefore, in the absence of this leading witness, we observe the external causes operating, knowing their tendencies to excite sensations—when, also, we notice them followed by movements of adaptation, implying sensation, volition, and judgment, we have circumstantial evidence enough to warrant the conclusion that they have taken place. In the former case, we reason from the known laws of the causes to their effects; and in the latter, from the effects to the causes.

The simple and natural inference which we have already made (page 49) from the structure of the nerve, and the nature of the cause acting on its peripheral extremities, enables us to account for the interposition of this tissue between the muscles and the surface of external impressions ; and opens the way for an explanation of the fact, that irritation of the cut extremity produces contraction of the muscle with which it is connected. It is not mind, as possessed of the abstract power of perception, &c.—which power is called into exercise by virtue of external physical impressions, enabling it to be acted on by objects in the world around it; but mind, as having added to this and its other intellectual powers, the power of muscular contraction, by which it reacts on those external objects, that is capable of fulfilling the purposes of its incarnation. It, therefore, having as it unfolds itself in the life of the body, constructed each organ with mechanical adaptations for its special offices, and among them, the muscles, holds itself in union with these last, as the contractile power, the 'vis insita' of Haller. It is there, in this union, that it receives the external impressions, *directly* in the peristaltic muscles, and *mediately* through the nerves in the voluntary, and contracts them according to the nature of the sensations experienced.*

As it is frequently experiencing sensations in this way, especially in that class of animals from which we have taken the illustration, a habit of action is formed, and it cannot but feel similar sensations and contract the muscles, though unconsciously, on any physical agitation of the nerve. The fact of the contraction of the muscle, when the branch of the nerve leading to it is irritated, is, therefore, one of precisely the same character, when fully analyzed, as that of the specific sensation being felt, when the specific nerve is stimulated. They are both the results of association.

To conclude. We have specific sensations in the mind on physical agitations of a nerve, not because the sensation was originally associated with the physical agitation, but because the agitation has become associated with the sensation. That is to say, the sensation is the real and the primal, and the agitation is the contingent and the secondary. In other words, the mind, having its attention called to the object by the physical impression, intuitively perceives it. It notes the agitation constantly recurring in the nerve, while it attends, and associates it with the sensation. Subsequently, a similar agitation arising, it spontaneously calls up the same sensation. So, in muscular contraction, the mind, holding itself in union with the muscle, as the contractile force, is roused by the physical agitation propagated from the surface along the nerve ; it attends, and feels the sensation, and contracts the muscle accordingly. Subsequently, a similar agitation arising, though from a cut extremity irritated, it reproduces a similar sensation spontaneously, and contracts the muscle. The disordered sensations and perceptions are thus *incidental* to the law by which we experience true sensations. The disordered muscular contractions are also incidental to the law of regular muscular movements. Unless it be so, if our sensations be not based on the true external stimulus, if they spring from a mere subjective property of a nerve, capable of being excited by any stimulus whatever, and if our muscular contraction spring from a similar property, then, indeed, have we no reason to believe in the existence of a world without us, and our movements must be purposeless and aimless. The skeptic, driven from the field of psychology, may transfer his battle ground to physiology, and barricading himself behind these vital properties of nerves, renew the contest; yet nothing can be more surprising, than the eagerness with which distinguished philosophers, and professed realists, have exhibited to fortify him on this vantage ground, by acknowledging the theory which rests on them.

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* There is no more reason to regard the nerves possessed of a motor power, because impressions made on them are followed by contractions of the muscles in which they terminate, than there is to regard the lining membrane of the heart, or of the alimentary canal, possessed of a motor power, because the muscular structure in contiguity with them contracts when they are subjected to like impressions.

It will be readily seen from the remarks above made on consciousness, whence has arisen the idea so generally prevalent, that the brain is the seat or organ of the mind. It is the uniting medium between all the organs of sense, and all the muscles. It is therefore indispensible to all the sensations and to all the voluntary movements of which we are conscious. Sensation can only be when the mind is in an intellectual state, and motion must be preceded by judgment as well as volition, implying also an intellectual state and exercise. Hence, this state must coincide with the activity of the brain, because the brain must always be active when sensation and volition are experienced. And as the intellectual faculties improve by exercise, the greater the number and variety of the sensations, the greater the number and complication of the motions; and the oftener they are repeated, the more powerful the mind becomes; and the greater the number of nervous fibres from the organs of the senses, and from the muscles, and the longer they are required to be kept in a state of tension from the same point, the more powerful the central organ must be. Hence, among animals, the mind of man appears the most expanded, and his brain the largest, correlatively to this multiplication of mental exercises, and this increase of nervous action, without the one being necessarily dependent on the other. And since the greater or less degree of the intellectual state called into existence by sensation, &c., is habitual with a greater or less degree of brain activity, (the nutrition of this organ being more active, the more it is exercised,) we find another correspondence between the size of the brain, and the mental power of individuals.*

As to delirium, we have no reason to regard that symptomatic of disorder of the brain, more than of other important organs. In fever, erysipelas, traumatic gangrene, pneumonia, pericarditis, and many other diseases, where the brain is not affected, it is a common symptom. While it is absent, or rarely present, in hydrocephalus, apoplexy, and in the early stages of some decided inflammatory diseases of the brain. The integrity of the brain within certain limits, is undoubtedly necessary to those operations which the mind performs with consciousness. It is therefore necessary in man to distinct sensation and volition, and also to memory, because memory is dependent on consciousness. But no one has a right to say, that when consciousness is lost, all the powers of the mind are gone, for that would be confounding the mind with consciousness.

The imperfections of this theory appear no where more strikingly, than when its advocates come to explain sympathy and shock. If the vital actions depend on the vital properties of each individual part, there can be no more of them ever witnessed in the system, than what naturally flow from the *sum* of the vital properties in all the parts. When death takes place from the loss of a limb, or from any injury of an important organ, how happens it that this produces the loss of the vital properties of other limbs and organs? Why, in certain animals, can the brain and spinal cord be slowly and carefully removed without destroying the contractions of the heart, while the sudden destruction of it annihilates them at once? When vital properties are gone from the system, they are gone; and it can make no difference to those that remain, whether they are taken away suddenly or slowly.

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*The idea that there must be a specific change in the nutrition of the brain, for every thought or act of the mind, is one of the grossest absurdities ever conceived.

When death takes place, as it ordinarily does, gradually, there is coagulation of the blood and rigidity of the muscles of longer or shorter continuance; but when it takes place suddenly, as by a stroke of lightning or by a violent blow over the stomach, these phenomena manifest themselves imperfectly, or not at all. What is the medium by which the influence of the impression made on one part, reaches distant parts? Can we conceive of it, as other than a vital principle, which energizing in all the organs, in some cases, experiences such a sudden interruption to its activity at one point, as to paralyze it every where? It has been found convenient, by some of the leading physiologists of the day, to ignore as much as is possible the phenomena of sympathy, and when their consideration is forced upon them, it urges them into the inconsistency of calling to their aid the word vitality, or some equivalent, which they drop as soon as they surmount the difficulty. Dr. Carpenter gives us no chapter on sympathy; the word indeed, does not find a place in his index of subjects. His system, without it, is complete as a system of vital properties; but will it be admitted as a system complete of the laws of life? In a chapter "on the influence of the nervous system on the organic functions," however, he details instances of the effects of the emotions, and other states of the mind, in disturbing the processes of secretions and nutrition; and having proved the independence of these processes on the nervous system, in a former part of his work, he now, without a show of reasoning, and in opposition to the a priori probability, that the cause that produces a change in a secretive or nutritive action, is a modification of the cause that maintains such action, attributes them to different states of the nervous power. This inconsistency is paralleled only by the admission on his part, of the influence of the imagination of the mother on the fœtus in utero; and, as there is no nervous connection in utero between the two, making the blood the medium by which it passes from one to the other. Here we have not merely a transmutation of mind force into nerve force, and a transportation of said nerve force to the terminus of nerve conduction, but a change of carriages, and an embarkation on a new element, before the traveller reaches his final destination. Chameleon like, as are the properties claimed for this unique energy, it was hardly to be supposed that this adaptation to circumstances was one of them.

I shall close this essay by subjoining some of the most important conclusions to which I have been led, and which will serve to assist the reader to fix in his mind the chief points in the argument. All but two of the following propositions are illustrated in this essay. The sixth is proved in the first, and the tenth will be found discussed in the third and last of the series.

The doctrine of vital endowments is,

1st. Opposed to the general analogy of nature.

2d. It is opposed to the analogy of the other organs and organic systems in the body.

3d. It is contradicted by the structure of the nervous system, by the mechanical relations of its several parts to each other and to other organs, and by the nature of the causes operating physiologically to excite its functional activity, or pathologically to disturb it.

4th. It violates the law of proportion between the size of the nervous centres, and the complexity of their functions, by assigning very complicated functions in higher animals, to parts, in which the same size is preserved, as in the corresponding parts of lower animals, in which the analogous function is extremely simple.

5th. In order to preserve its consistency, it denies to the invertebrated class of animals mental qualities which they most certainly possess. Thus, Carpenter, while he allows intelligence to beasts, birds, and fishes, denies it to ants, bees, and spiders, because they have no brain.

6th. The persistence of a function after the destruction of the organ on whose vital endowment that function depended, as the continuance of the power of voluntary motion after the destruction of the whole anterior part of the spinal marrow, a fact admitted, and of a positive character, is a decided refutation of the whole theory.

7th. The mechanism of voluntary motion, which it sets forth, is absurd.

8th. The distribution it makes of the sensitive properties throughout the nerves, is unphilosophical.

9th. It fails to account for *all* the phenomena which take place in the human body, and which are usually referred to the nervous system; such events as shock, sudden loss of vitality, and many of the phenomena of sympathy remaining unaccounted for, by it.

10th. The inconsistencies and contradictions of those who undertake to investigate and fix these vital endowments of nerves and nervous centres by means of physiological experiments, and pathological observations, are such as could not take place, did they possess the true key to the explanation of the facts which they witness.

11th. A comparison of the phenomena of association with those of instinct, will show that the apparent fixedness of the sensibilities of the specific and other nerves, can be explained as well by regarding them as mental faculties instinctively associated with physical excitements of nerves, as by supposing them due to inherent properties of the nerves themselves; and if so, the supposition of the existence of such properties is a gratuitous assumption.

12th. And with regard to the well-known fact that when the cut end of a motor nerve (so called) is irritated, the muscle with which it is connected contracts,—by far the strongest argument in favor of the doctrine of vital endowments, if we adopt a view of the nature of the union of the mind with the body, which has been held by many of the most distinguished ancient as well as modern philosophers, viz., "that the mind is all in the whole body, and all in every of its parts," instead of locating it in the brain or any other part; we can then conceive of a mental act intervening between the excitement of the cut end of the nerve, and the contraction of the connected muscle, on which, and not on any property of the nerve, the effect is due.

13th. Finally, of those facts which have loosely been held to prove that the brain is the organ of the mind—such as the correspondence between the size of the brain and the intellect of the species, or of the individual; the sense of fatigue in the head that follows long-continued exercise of the mind; delirium, attending an excited condition of the nervous system; impairment of the memory in disease of the brain; loss of the powers of sensation, volition and consciousness, in concussion and compression of the brain; they only serve to show a connection, perhaps fortuitous, between the functional activity of the brain and the exercise of the mind. Sensation and volitional guidance of the contractions of the muscles are both intellectual operations; and as the activity of the brain is necessary to those, so it becomes associated with, and is favorable to, the activity of all the intellectual faculties.

ESSAY III.

This essay was read before the Massachusetts Medical Society at its annual meeting, May 27, 1856, and is here given without alteration.

Gentlemen,—I suppose that it is not unknown to some of your number, that I have ventured to call in question the prevailing doctrines of the physiology of the nervous system, and have advanced a different one of my own, relative to this most important branch of medical science. Having been for some time, desirous of drawing the attention of this body, as a society, to the subject, in the hope that it will see enough of probability, if not of truth, in what may be offered, to warrant some action, on its part, calculated to give it currency, it was with feelings of gratification that I accepted an invitation from your committee, to prepare a paper to be read at this meeting. It cannot be expected that, in the limited time allotted to me on this occasion, I shall be able to present a full view of the arguments on either side of the question. I must therefore refer to the Boston Medical and Surgical Journal for the years 1854 and 1855*, for a portion of them. And I hope soon to add a second part in the form of an Essay,† which, along with the first, will furnish a body of evidence so complete, as (in my opinion at least,) to leave any man without excuse, who continues to adhere to the views, which, hitherto, we have passively received from abroad, particularly from the school of Bell and Marshall Hall.

I propose, therefore, to-day, to show by a superficial glance at the origin and results of the mode of inquiry now pursued, that if this great mystery of the nervous system is ever penetrated, it must be by a channel altogether new. This, if time is permitted, will be followed by an outline of my own views, in which, by the aid of the diagram,‡ I shall endeavor to illustrate that portion of the proof, which is derived from the correspondence between the principles, and the mechanism of the nervous system, and which may be denominated the anatomical proof. And after this, I shall endeavor to point out some of the inconsequences of those experiments of Bell, Muller, Kronenburgh, &c., which have been relied on as proofs of the sensitive and motor functions of the spinal nerves.

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* The first of these Essays.

† The second.

‡ A large Diagram, painted on canvass, was exhibited to the society, of which the one inserted towards the close of this Essay, is a copy.

The idea that a part of the nerves were destined for motion and a part for sensation, originated at an early period in the history of medicine. The terms neuroy aisthetikoi, and neuroy kinetikoi, invented to express these relations, indicate its prevalence among the ancient Greeks. It seems, however, to have arisen rather from conjecture, than from a direct process of reasoning founded on facts; and from the want of a clear discrimination of what pertained to the mind, and what belonged to the nerves, in the process of sensation, and in the accomplishment of motion, to have been held in a vague and often inconsistent manner. In the absence of all positive knowledge on the subject, it was the most simple and natural way of accounting for the occasional loss of sensation without the loss of motion, and the reverse: facts, which must have forced themselves on the attention of the earliest physicians.

There appears to be this difference in the manner, in which this opinion has been entertained by the ancients and the moderns, respectively. By the former, it was held under, and subordinate to, the doctrine, that the soul or spiritual principle was the chief agent in the formation of the body, and the active recipient of all the sensations received through its medium, as well as the efficient cause of all the movements which take place within it, whether voluntary or involuntary. They therefore believed that it was some modification of physical structure, or mechanical condition, by which one nerve was adapted to one office and another to the other.

Thus, it was the opinion of Galen, that the relative degrees of hardness or softness of a nerve, determined its function in this respect. And he even went so far as to suppose that the same nerve, in one part of its course, may harden so as to give rise to motion, and in another, may soften so as, by its greater impressibility, to give rise to sensation.

The moderns, on the contrary, maintain that there is a peculiar power or endowment inherent in the nerve, over and above, and independent of its structure, and which may be essentially different in two nerves of the same structure.

The dividing line between these two sets of opinions, may be truly said to be the writings of Haller. This distinguished author, while he believed neither with those who went before, nor with those who were to come after him, and while he expressly declared that he "cannot admit a distinction between the two systems of motory and sensitive nerves," laid the foundation, by his doctrine of irritability, or vis insita, in which he first gave prominence to the idea of a power in a part, which had no conceivable connection with the structure of that part, of the very doctrine in question. It was but a step, when the limits which circumscribed our reasoning on these subjects, were once transcended, to pass to the modern platform of vital endowments. If there is a vis insita in a muscle, which bears no conceivable relation to the structure of that muscle, then why may there not be another vis insita in a nerve, which bears no conceivable relation to the structure of that nerve? If in the nerve, so in the fibre; if in one fibre, so in another; if in the nerve or muscle, so in the ganglion; if in one ganglion, so in another.

It was reserved to Sir Charles Bell to take this step. According to him every nervous fibre has its peculiar vis insita, or vital endowment, by which its function is effected, and which it is the end and aim of physiology to discover.

This belief has been entertained in conjunction with another of analogous origin, and the conjoined influence of the two on the fortunes of the physiology of the nervous system, it is impossible to overestimate. This second idea is substantially as follows. It is universally supposed—at least, in the modern systems—that the influence of external impressions on the organs of the senses, is transmitted to, and exhausted on, the centres, with which these nerves are connected. And that in these centres a new agency is called forth, which either acts on the motor nerves, and is by them communicated to the muscles, in case a motion is called forth, or excites an idea in the mind, if no motion ensues.

These two fundamental ideas have entered as a priori conceptions into the minds of all physiologists, and have given shape and coloring to their explanations of experiments, and of the facts which have been witnessed in connection with the disorders of the nervous system. Every experimenter starts with the belief, that one of the nerves he experiments on, is either motive or sensitive, and that every ganglion is an originator, and interprets his experiments accordingly. They therefore constitute, as it were, the mould in which modern neurology is run. Now one issue that I make with physiologists, is, that they have assumed these principles without proof—that while there is extant no train of reasoning grounded on facts to prove either of them, reasoning I mean, in which the successive steps from premise to conclusion are intuitively seen, they have universally proposed to themselves as questions to answer, not whether there are any sensitive nerves and whether there are any motor nerves, but which nerves are motor and which are sensitive; not whether there are any occult powers of motion or of thought in the ganglions, but which of them has this, or that power of motion, or of thought.

Further; in carrying on these investigations, they have been partial in their selection of facts. They have confined themselves entirely to the consideration of the sensible phenomena, while that large class which reveal the existence of a spiritual principle within the body, have been overlooked. These facts, again, they have attempted to arrange and explain, with a single eye to the mere relations of antecedence and consequence, and without any reference to the known laws by which physical causes act. The consequence has been, that, in no case, have we any assurance that the real cause in the production of a given phenomena, is not a mental one, instead of the physical fact assigned.

These are great and important errors, which, as I conceive, in a logical point of view, lie at the foundation of the system.

It is now nearly a half century since physiologists have been engaged in the path of inquiry marked out by Bell, which they have pursued chiefly by means of experiments performed on living animals. If there is one department of physiological science which has been cultivated with more assiduity than another, it is this. In England, and on the continent of Europe, it has been the field on which the aspirant for fame has indulged his fondest anticipations, and where even national rivalry has condescended to intermix with the jealousies of would be discoverers. It is fair, therefore, to presume that if this is the true philosophical principle, and the method by vivisections the true method of developing it, sufficient time has elapsed for important results to have been attained. Indeed, it would not have been considered unreasonable, thirty years ago, in view of the zeal and ardor then beginning to be manifested, to have anticipated, before now, the complete solution of the problem. The expectation might then have been reasonably indulged, that long ere this, if the question was put to us, what is the office of the brain, cerebellum or spinal cord, or any particular ganglion or nerve, we could have answered as promptly as, in the days of boyhood, we were wont to answer the questions in the Assembly's shorter Catechism; and that candidates for Medical degrees, would now be done writing theses on the subject.

A true physiology of the Nervous System, should,

1st. Give a reason for every anatomical point in its structure.

2d. It should give a good account of physiological experiments, and pathological facts connected with this system.

3d. It should throw light on the treatment of nervous diseases generally.

How far these indications have been fulfilled by the system now believed in, I propose to inquire as briefly as the state of the case will allow me.

And with regard to the first of these points, the proposition that I lay down, is, that while there is not a single part, the structure and relations of which are so definite and constant as to entitle it, from its external appearance, to the character of an organ, whose function may be said to be known with completeness and accuracy; some, which have the appearance of being fundamental and important, are now the subjects of vague speculation, or of the most crude conjecture, as to their object and end in the economy.

When the physiologist asserts that the brain is the organ of the mind, he neither attaches a definite meaning to the phrase he uses, nor is he able to give a reason for the faith that is in him. By a species of scientific license, it is allowed for one to say, in order to escape the imputation of materialism, that, by the term organ, he only means the instrument through which the mind is able to manifest itself, although he gives no reason why the mind needs an instrument to think with, and although he points out no connection between the mind, as motive power, and the properties of the brain, as adapted to the manifestation of that power, but, on the contrary, submerges the former in the latter. For another, who despises such hypocritical meanness, it is lawful to say that the brain secretes mind as the liver secretes bile, without filling up the analogy by pointing out the gall ducts through which thought flows, or the gall bladder, in which it is held as in a reservoir, in its quiescent state. For each of these views, it is a sufficient proof that pressure on the brain destroys intellectual manifestation, or an inflammatory state of that organ gives rise to delirium, notwithstanding a volume of metaphysics might be written between these premises and the conclusion. Nor is there any incompatibility with either doctrine, in carrying on mental culture in a continuous field over the superficial area of the convolutions, or in variegating the surface by dividing it into small patches, and raising diverse crops of intellectual faculties. In a word, there can be no better proof that the physiology of the brain is as yet in the embryotic state, than the fact, that a scheme like phrenology, can obtain countenance and support from scientific men, and that itinerant mountebanks may be seen daily scouring our country villages, and supporting a worthless life, by selling good intellectual and moral characters at the rate of fifty cents a head. Such systems, like the ancient astrology that preceded the knowledge of the laws of the motions of the heavenly bodies, are the fungi and mushrooms that sprout up under the shade of general ignorance, out of the semi-vitalized materials of thought, that accumulate and lie mouldering until some general principle is discovered, to comprehend and cover the table. How Sir Charles Bell found himself obliged to retract the first, and therefore the most natural inference which he drew from his operations on the fifth, viz: that it was a nerve of motion, and to adopt the opposite conclusion, to which he was driven by his preconceived opinion, that it must be either the one or the other;—how the fifth finally is made exclusively sensitive by borrowing a few motor fibres from the seventh;—and how it repays this obligation, by contributing a few fibres to the seventh, to save its character, and render it just a bit sensitive;—how the glosso-pharyngeal is afferent wholly, only it sends a twig to the stylo-pharyngeous, and palato-glossal muscles;—how the superior laryngeal would be altogether sensitive, did it not send a twig to the crico-thyroid muscle, and inosculate with the inferior laryngeal. In short, how there is not a single nerve of any importance, to which either of the words sensitive or motor, apply in its completeness and totality. An if or a but, a provision or an exception, must qualify every such assertion.

If there are such powers or endowments in the nerves or centres, as we are called upon to believe, the method by vivisections is doubtless the true method of attaining a knowledge of them; and if so, then the conclusions drawn from these experiments, should harmonize, and not contradict each other. It is fair, therefore, to presume that the measure of agreement or disagreement, which obtains among different experimenters, is a good test of the soundness of the theory.

The history of these experiments is too familiar to my audience, to render it necessary that I should go into extensive detail in regard to them. Suffice it to say, that they are an ever recurring series of inconsistencies and contradictions. Does a man wish to arrive at the summit of human knowledge, "that nothing can be known," let him study these experiments; for if he is so fortunate as to have any connected ideas relative to the office of the nervous system previously, the reading of these will plunge them into chaos. If he keeps up with what is called the progress of the enquiry,—that is, if he changes his opinions according to the results of the latest and most approved experiments, he will, in the end, be surprised at his own ficklemindedness. It is impossible for a physiological writer, in giving a systematic account of these vivisections, to tell a straight story, and arrive at any apparently legitimate conclusion, without adopting some favorite experimenter, and discrediting the labors of others, perhaps equally worthy of respect, base all his inferences on the researches of his protege.

It requires the talents of a lawyer, rather than those of a philosopher, to make anything of the evidence which they afford. The witnesses must be cross questioned,—doubts must be thrown on the capacity for observing of one, on the capability of another to perform the operations which he reports himself to have done,—on the credibility of a third; until the testimony of a sufficient number is ruled out of court. Then must commence a long course of special pleading to harmonize the remaining facts.

These remarks are amply confirmed, and illustrated, by the manner in which was established the very doctrine which has been regarded as the great physiological achievement of our day, and which has given the chief impetus to this mode of investigation.

In 1821, Sir Charles Bell publishes experiments, from which he deduces the functions of the anterior and posterior columns of the spinal cord. A year afterwards, Magendie publishes, and attaches a qualifying adverb to each of Bell's positive affirmations. Some time after this, Muller and Kronenburg, uneasy at the state of indecision and doubt in which the subject is left, again repeat these experiments, and the wish being parent to the thought, succeed with great difficulty and labor, in forcing out a plausible case for Bell. In the mean while, Bellingeri undertakes, independently, similar experiments, and runs counter to them all. It is found, therefore, on summing up, that the weight of evidence is in favor of England and Germany; France and Italy are but two against three. Magendie, in order that the question may be decided, must be discredited, and Bellingeri overlooked. This is accordingly done; and the sensitive and motor functions go on their way, a little halt indeed, but still rejoicing. Instead of regarding these discrepancies as proof that some of the elements necessary for the decision of the question, were yet wanting, the weight of authority, and numbers is invoked to press down and stifle further enquiry. Magendie, in return for his stubbornness in reporting facts instead of theories, is gravely told by the British Journalists, that he is free from the first qualification of a philosopher. The Italian experimentalist is treated with hardly less respect, and physiologists generally, eager to be relieved from the uncomfortable state of suspense in which they were previously held, acquiesce in the charge.

Such, I conscientiously believe, is a fair representation of the mode in which this celebrated theory was foisted on the scientific world. Lest, however, its aptness to illustrate the point which I had in view, may be contested, on the ground that vivisections being then comparatively a new method of enquiry, the rules to be observed, and the precautions to be taken, in conducting them, to insure accuracy in results, were little known, I would call to mind a more recent example.

"The boldness and apparent exactitude of the experiments, as well as the important conclusions to which Van-Deen had arrived in 1841," (says the British and Foreign Review,) "led Stilling to repeat them on the following year. With very few exceptions, this latter author declares the experiments of his predecessor to be false, and consequently his conclusions to be erroneous."

These two experimenters are regarded as of high authority, and they pride themselves particularly on their accuracy and dexterity in such operations. It is not a single and casual experiment on which they happen to disagree, but a great number, performed nearly at the same time, and under similar circumstances. Is it probable that it is the fault of the men, or of the system, that they disagree so cordially?

Of like import, is the testimony of Mr. Noble, a writer of great ability on the phrenological side of the question, who presents the subject so clearly, and so much to the point, that I am tempted to quote a paragraph entire. Speaking of the experiments made on the cerebellum, he says, "It will thus be seen that no two of the above instances presented any thing like coincidence in the result; but that on the contrary, direct contradictions occur. Rolando's Paralysis is met by Bouillaud's no Paralysis; Flourens' inability to regulate movement is counterpoised by Magendie's capability, confirmed by Fodera's experience; and the same contradiction is seen throughout the entire history of these vivisections. There is not a single fact recorded by one operator, which is not counteracted in its tendency to any conclusion by the experience of some of the others."

These contradictions are admitted by the eminent writers and philosophers of this school, not only virtually, by the precautionary rules, that they are continually suggesting to the experimenters, and by their labored attempts to reconcile the experiments themselves, but by their direct confession. "The results obtained by different experimenters on the glosso-pharyngeal nerve," observes Carpenter, "are so strangely at variance, as to lead to the belief, that they had operated on different nerves." Nearly equally contradictory, are the reports, as to the functions of the spinal accessory, according to the same author. "The experimental history of the par vagum," says Dr. John Reid, "furnishes an excellent illustration of the numerous difficulties, with which the physiologist has to contend, from the impossibility of insulating an organ from its mutual actions and reactions." Quotations of a similar character might be multiplied to an indefinite extent.

Such writers show by their frequent excuses and devices to account for these discrepancies, that they begin to feel the awkwardness of their position. All sorts of reasons are given for their failures to arrive at fixed and certain results. The blame is laid now on the experimenter, now on the inherent difficulty of determining the question. They are evidently becoming conscious that their search after truth, is, to use a familiar simile, something like the seeking of him, who looks for a needle in a hay-stack. Still, they console themselves with believing that their labor, though arduous, is yet not wholly desperate. They yet hope that by carefully taking up each straw of hay singly and laying it aside by itself, such perseverance will finally be rewarded with success.

But there is a different reason from any that they have yet offered, why they have not found it. The needle is not there. If it had been, they would have felt it prick before this time. There *are* no motor nerves. There *are* no sensitive nerves, in the sense in which these terms are commonly understood. And all search after what does not exist, however laborious, must always result in failure and disappointment.

A few months since, my attention was drawn to an article in a well known Medical and Surgical Journal, entitled, "Discovery of the functions of the spinal marrow by M. Brown Sequard." As a matter of course, I felt interested to know what this discovery was. On examining the article, I found that this gentleman had ascertained, that section of the anterior column did not prevent motion,* and that section of the posterior did not prevent sensation. The inference therefore was, that the anterior column was not for motion, and the posterior not for sensation. How could this be the discovery of the functions of the spinal cord? He had found out what the spinal marrow did *not do*. Not what it did! The public care little for such negative knowledge. It wishes to know what the spinal marrow does! What it does not, it is well content, should it remain untold.

Had the editors of the Journal referred to, turned back their own pages a year or two, they would have found a complete explanation of the experiments of M. Sequard, in the true exposition of the functions of the spinal cord, along with that of the rest of the nervous system. I would not be understood, however, in claiming what belongs to me, as wishing to imply any censure on the gentlemanly editors of the Boston Medical and Surgical Journal. They had not charge of that periodical when the articles referred to were published ; and few think of looking into our home made medical literature for a new idea. They erred from an excess of generosity, in bestowing on the French Physiologist a title to which he had no claim.

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* I find on consulting my copy of the Journal which was mislaid at the time of writing the above, that I was guilty of misrepresenting the conclusion of M. Sequard under this head. M. Sequard does not say, that, section of the anterior column did not prevent motion, but that, its integrity did not prevent loss of motion. He could not, indeed, assert the former without denying established facts. The experiments of this gentleman, when collated with others, and interpreted by the dominant logic, prove that the anterior column is both for motion, and not for it.

The experiments of M. Sequard were chiefly interesting as proving, that, after a lapse of thirty five years, vivisections had come round to the point from whence they had started. As they first stood, they contradicted the anatomical relations between the columns and the cerebellum. As they now stand, they contradict that relation between the nerve roots, and the columns, or else they are a complete contradiction of Sir Charles Bell's first experiments.

They also furnish an apt illustration of the nature and value of vivisections in general. They confirm the fact that these last can never be made an instrument of discovery. So long as they are used for this purpose, they will only serve to set up men of straw, to be knocked down again. The most that they can do, is to confirm, or perhaps to correct inferences drawn from other sources ; but inferences, based wholly on them, must ever revolve and double on each other, in endless circles.

But aside from these experimental contradictions, there are facts in pathology, which cannot be comprehended by the sensitive and motor theory, but which demand a broader general principle for their explanation. If the function of a nerve depend on a power inhering in itself, then it can make no difference to that function, in what manner the nerve is destroyed. When the continuity of the nerve is once broken, the function is gone, no matter whether it is the slow work of disease, or of sudden injury. But if the nerves are placed in the foreground, and the real actor is behind the scenes, the supposed functions of the nerves being quasi functions merely, then we may expect a difference according to the attending circumstances. The principle of Bell may serve to explain how motion is lost, when the anterior column is accidentally severed in man. But when, as in the case reported by Stanley, (in the Medico-Chirurgical Transactions,) there is loss of power of moving the inferior extremities, coincident with disease of the posterior columns throughout their whole extent, it fails altogether. So, also, it answers to account for the complete loss of both sensation and motion, below the part, when the whole cord is divided with a sharp instrument. But its inadequacy is again illustrated, when, as in the case reported by Dr. Nairne, where the spinal cord becoming softened by a slow process of disease through its whole thickness, a degree of motion and sensation remained below.

The consequences of lesions of the nervous system vary, not only according to the seat and manner in which the injury takes place, but also in their recuperative tendency ; and we want a theory that is able to explain the generalities among these consequences. We want a theory of paralysis, for instance, that will explain why motion is lost much oftener than sensation ; and why, when both are lost at the same time, sensation is oftener and sooner recovered than motion. We cannot rest satisfied with the amount of knowledge afforded by one, that limits itself to telling us that either or both may be lost at the same time. We want a theory that will afford a reason for the fact, that in a very large proportion of cases of partial or complete recovery from palsy, the leg acquires the power of motion first, while the hand either acquires it slowly and imperfectly, or remains completely paralytic. We want a theory by which we can understand how, while disease of the cerebrum, or cerebellum singly, is accompanied by palsy on the opposite side, should they both become diseased, in their alternate or diagonal halves, the palsy, (if it be true as Andral asserts,) is opposite to the diseased hemisphere of the cerebrum. A theory thus comprehensive, would not extend the domain of speculative physiology merely, but would have an important practical bearing. But no such theory can be based on vital endowments. The facts just referred to, indicate a want of fixedness in the nature of the powers producing them, such as is incompatible with the idea of their being inherent in any organic structure.

There is, however, one conclusion, of a less scientific character, which the impartial reader may found on these experiments. It is, that they are more pertinent as a matter of discussion to the "Society for the prevention of cruelty to animals," than to the Royal Society, or to the French Academy. In the eye of humanity, if the frogs appear as a nation of croakers, it is not without sufficient reason. One might almost believe, when he contemplates the merciless cruelties that have been perpetrated on this unoffending little animal, that the peculiar plaintive note, with which he chants his morning and evening song, was given to it, that it may eke out by anticipation the measure of its just complaint against the authors of these outrages. The dog too, may urge in his plea, not only the charge of bootless inhumanity, but that of black ingratitude. From the day when he followed Adam out of Eden, to the day when he alone of the household of Ullyses, recognised and welcomed the long absent warrior, and from that day to the day when he followed, as a solitary mourner, the last pauper to his long home, he has been the devoted friend of man. While modern human philanthropy stands aloof, and barks at evil from a distance—while it ebbs and flows with the tide of fashion, canine philanthropy is self-sacrificing and always constant. To avert danger from man, for the protection of his person or property, the generous dog offers limb or life. He will lay his life at the feet of his master if thereby he can be of benefit to him, but he has a right to demand, that the sacrifice should not be a vain one. The dog, who dies a victim to hydrophobic fear, has the consolation to think that among the remote possibilities of the future, his death may be of benefit to man and the craving of his instinct is satisfied. But no such consoling thought cheers the unhappy victim, amidst these scientific tortures. He feels not only that he is a martyr, but that he is a martyr to a false religion. His sagacity has already taught him, if human sagacity cannot teach his persecutor, that he is put on the wrong scent, or is barking up the wrong tree; and it especially regrets him, that in yielding up his life amid excruciating agony, he is able to give testimony to no great truth, which is to redound to the benefit of mankind.

Although it is presumable that correct ideas of the physiology of the nervous system would be felt, in its influence on the treatment of nearly every disease in the catalogue, it is in the class attended with disordered motions and sensations, that its greatest triumphs would be witnessed. Here, therefore, in the practical superiority of the physicians of our time, over those who dealt with the animal spirits, as they moved over the nerves, should we look for an experimentum crucis in favor of this theory. Yet, were we called upon to point out the improvements which modern discoveries have contributed to the treatment of disease, we certainly should not seek among the neuroses for examples. Hydrophobia still maintains it old position as the great opprobrium. Tetanus to this day, as in the days of Hippocrates, is declared by some of the most eminent among physicians and surgeons, incurable. Chorea is treated on the same principles, as in the time of Sydenham, and with no better success. Epilepsy has no hope as yet, but in a blind empiricism. And the word hysteria has not grown out of fashion as a cloak to cover not only the sin which is to be winked at, but a multitude of practical errors more serious in their consequences. Even the section of the nerve in neuralgia, from which so much was once hoped for, is fast becoming obsolete. If some little advance has been made in the application of anesthetics and narcotics to these diseases, it has resulted from experiments made empirically, and in no way from a knowledge of their operation on the supposed vital properties of the nerves.

Nor, as I conceive, is it difficult to divine the reason why the therapeutics of spasmodic diseases have not kept pace with progress in other departments of the healing art. It is generally conceded that diseases are but aberrations of the workings of the causes which give rise to the normal phenomena, owing to some excited or perverted condition of their action, and that they still obey the same laws. Now, as the muscles are supposed to be contracted physiologically by means of some power generated in the nervous centres, and propagated thence to them, it follows, that all disordered contraction must arise from some disturbance in this power, either in the mode in which it is generated there, or in the manner in which it is distributed, more especially in the former. Hence, we have as the cause of the muscular movements necessary to the act of swallowing, something generated in the medulla oblongata; and as a consequence, the pathognomonic sympton of hydrophobia, spasmodic swallowing, results from some disturbance in the process by which this something is generated. The seat of this disease is therefore said to be in that part. In like manner the seat of tetanus is the spine; and hysteria and chorea are also found to depend on spinal irritation. And men who reason and talk thus, flatter themselves that they have some connected ideas as to the nature of these disorders.

The doctrine which we have referred to, has been held as the immediate or direct cause of spasmodic contraction of the muscles, while the proximate cause, or that which gives rise to the disordered action of the centres, has been made a subject of discussion. It has been an open question, whether the disturbance in one centre sprung from a sympathetic affection with another centre, from irritation transmitted through afferent nerves, or from some poison in the blood. But a codicil is about to be attached to the doctrine, which promises to reduce these secondary causes within very narrow limits.

Formerly, it was extremely fashionable to refer not only diseases, but healthy vital processes to the nervous system. Nervous irritation was a prominent character not only in the play of many local, but even constitutional disorders, while nutrition, secretion, calorification, as well as muscular contraction, must stop without the presence of the well known nervous influence. The spinal marrow, in order to furnish the varied powers for the duties dependent on it at this period, must, however homogeneous it appears to the natural, or microscopic eye, have exhibited on a transcendental analysis, as many meats as a turtle. But the real progress that has been made in physiology, that which, in fact confers on it the chief claim it has to the character of a progressive science, is the detaching, one by one, these processes from the nervous system, and the continual approach towards the limitation of its office to a mere secondary role in sensation and motion. But in proportion as the nervous system has lost in this respect, the vascular has gained. If a medical student were to commence his studies on the properties of the blood, by reading the most popular authors of the day, in order to attain the latest and most approved ideas on the subject, and to save himself the trouble of unlearning the errors he might imbibe from such worn out authors as old Hunter, would he come to the conclusion that the veins and arteries circulate a bland and healthy pabulum for the nutrition of the tissues, and for the excitation of the functional activity of the brain? Would he not, rather, regard them as parts of a grand system of sewerage, in which float all sorts of miasms, and corruptions, morbid poisons generated from within, or introduced from without, atmospheric poisons, the dank exhalations from Mother Earth, the exuvia of secreting organs, and filthy things generally, moving onward, not as though directed by some instinctive foresight towards the external outlets, but impelled by some new and unheard of error-loci, to discharge their accumulated lentor on the most delicate organs, and to derange the nicest vital processes and functions?

It is not enough, that small pox, measles, scarlatina, and zymotic diseases generally, should be attributed to some poison circulating in the blood. But epilepsy, which has been often traced to tumors on the nerves, to small substances, as a pebble in the meatus, and to tubercles, or other deposits beneath the skull, pressing on the brain,—hysteria, in which the deranged state of the uterine organs is often obvious,—traumatic tetanus, where the irritation sometimes begins in the part nearest the seat of the wound, and extends from thence to more remote parts, and where a local cause is always palpable,—hydrophobia, where, after forty days or upwards of quiescence, the bitten part is the first to feel the symptons, and where a consecutive affection of the mouth and throat is clearly indicated, first, by the pathognomonic symptom, being plainly a reflex irritation from that surface, and secondly, by the virus being reproduced from that part,—and, finally, chorea, where an undeveloped vital action, as a suppressed eruption, or the healing of a sore, appears on the face of things often as a probable cause; all these, it is the humor of the day to ascribe to some *specific* humor circulating in the blood, which, reaching with it the nervous centres, where the power of contracting the muscles is generated, disturbs, in its very initial being, the nature of that power, and thus gives rise to spasm instead of normal contraction. The grand therapeutical indication that springs out of this pathology is, therefore, to find out a counter-poison to each of these morbid humors, and by introducing it into the circulation also, start it on a wild-goose-chase after the noxious agent to which it bears affinity, that it may neutralize it either in its course through the vascular system, or wrestle with it in the ganglion; an indication which we cannot look to be fulfilled, before the retort and crucible have made known the chemical qualities of all these acrid humors respectively.

Having gone over the ground marked out at the commencement of this essay, however imperfectly and cursorily, the lesson which such a review inculcates, appears to me, to be a plain one, viz: that there is little encouragement for physiologists to continue longer in the same path of inquiry. If, after fifty years of laborious investigation, we are unable to lay a finger on a single point of the nervous system, and declare respecting it, the truth, the whole truth, and nothing but the truth; if experiments turn up contradiction, and nothing but contradiction continually; if we know no better how to cure nervous diseases, than the generation that preceded the oldest living inhabitant of the medical profession, then, we have gained nothing by departing from the principles of Galen and Aristotle.

The tree of neurology, planted on the doctrine of irritability of Haller, after the growth of half a century, presents, in anatomy, but a bare and naked skeleton, in which we are permitted to see no end in its structure, no comeliness in its outline. In physiology, it puts forth no green leaves, to cover as with a mantle the nakedness of its branches and to elaborate the vital juices drawn from its roots. In pathology, it blossoms not with promise, nor does it bring forth fruit in therapeutics.

* The view, which I would present to your consideration, to-day, is founded on the simple and natural properties, that spring from the structure of the nervous system; and on the plain and obvious powers of the mind, as revealed by consciousness. It supposes the nervous system to be employed as an *instrument* of sensation and motion exclusively, while, at the same time, the *powers* of sensation and motion inhere in the mind itself. And we shall have reason to see further, that its instrumentality in sensation is subsidiary to its instrumentality in motion. Being incidental to the great law, that all muscular motion in the body, whether voluntary or involuntary, is the result of the mind's immediate action, but directed by sensations conscious or unconscious arising from physical impressions. Instead of any occult power being transmitted from the external surface to the centre, and instead of anything new being generated in that centre and transmitted to the muscles, the physical impression alone is what is transmitted. According to a doctrine which has been maintained both in ancient and modern times, and which, if authority is to be invoked, numbers among its advocates, not *some* of the greatest, but *the* greatest names that the world has as yet seen, comprising those of Plato, Aristotle, and Galen, among the ancients, and Kant, and Sir Wm. Hamilton, among the moderns: that the mind forms the body, and in some mysterious manner is present to all the organs, and actuates each in the performance of its function. According to this doctrine, I say, that the mind, having formed the muscle, holds itself in union with it as the power of contraction. It is here, in this vital union, that it receives the impressions of external physical objects, and contracts the muscle, according to the movement to be made, adapted to the end it has in view, and guided by the sensations arising from those external impressions. Now, if we examine the modes in which muscular contraction takes place in the human body, we shall find that the simplest, viz: the peristaltic, which seems indeed to have come up into animal, from vegetable life—being nothing more than the circulatory motions of the latter, with the improvement that the addition of muscular tissue confers—we shall find, I say, that these contractions follow impressions made immediately on the muscles themselves. The impression of the food on the lining membrane of the alimentary canal, of the blood on the internal surface of the heart, of the fœtus on the corresponding

surface of the uterus, excite movements of adaptation in the muscles in contiguity with those surfaces.

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* Compare with what follows, the outline commencing at page 8.

But it is evident that such an arrangement could not be made for all the movements that take place in animals. The locomotion of the body, and the motions of parts independent of the rest of the body, require that the muscles should be so placed, that their power, when contracting, should be applied to a system of levers. And this will not allow of their being in contiguity with any one surface of sensation, much less with a number of specifically different organs, the impressions on which, are to give rise to the sensations which excite and direct their contractions. Since, then, the muscle cannot be brought into proximity with the surfaces of sensibility, some contrivance seems necessary to bring these organs into proximity with the muscles. This want is supplied by nerve. The nervous fibre is adapted, by its structure, to conduct, or continue on, the physical impression made on the sensitive organ to the muscles. But some farther provision is still necessary. If there were but one sensitive point, and one muscle to be contracted by the sensations arising from impressions made on it, a single nerve fibre, running direct from that point to the muscle, would be all that would be required. But inasmuch, as there are a *number* of sensitive points, and a *number* of muscles to be contracted and directed by the sensations so arising, fibres must run from each point to each muscle. Yet if they should run directly from point to muscle, so many would be required, and the crossings and interlacings with other muscles than their own, would so interfere with the lengthening and shortening of the muscles, that it is obvious that the machinery would work badly. It is evident, then, that a great advantage would arise from all the fibres arising from all the points on a given surface, being made to run to some convenient spot, and there to unite with fibres leading to the muscles whose combined action gives rise to the motion of a part, or to a series of motions. Hence we deduce the ganglion. The ganglion, (and I mean to include under this term all the centres,) is neither more nor less than a portion of space in which, by the vibratory impulses of arterial blood, as it passes into the venous state, a certain number of nerve fibres, coming from a sensitive surface, are made to unite with a certain number coming from muscles; and a state of tension is kept up, so that a physical impression made on one fibre, is disseminated throughout the whole. Thus, the ganglion is made to unite the nerve fibres, just as the fibres unite the sensitive and motor organs. The ganglion, and fibres terminating in it, form therefore a complete whole.* They constitute the only true nervous circle, uniting, as they do, the sensitive surface with the muscles to be contracted in consequence of sensations arising from impressions made on that surface. Now, the whole nervous system is but an aggregate of these circles, or apparatuses of union. And the study of its physiology consists, not in torturing animals, and inferring, from their sufferings, the properties of nerves, but in interrogating consciousness to find out what sensations govern the several classes of motions, and in tracing, by observation, the nervous connections between the organs of those sensations and the muscles that accomplish those motions. So, to ascertain the office of a particular nerve or ganglion, we have to disentangle the nervous circle of which it forms a part, from the aggregate, and find out its place in it.

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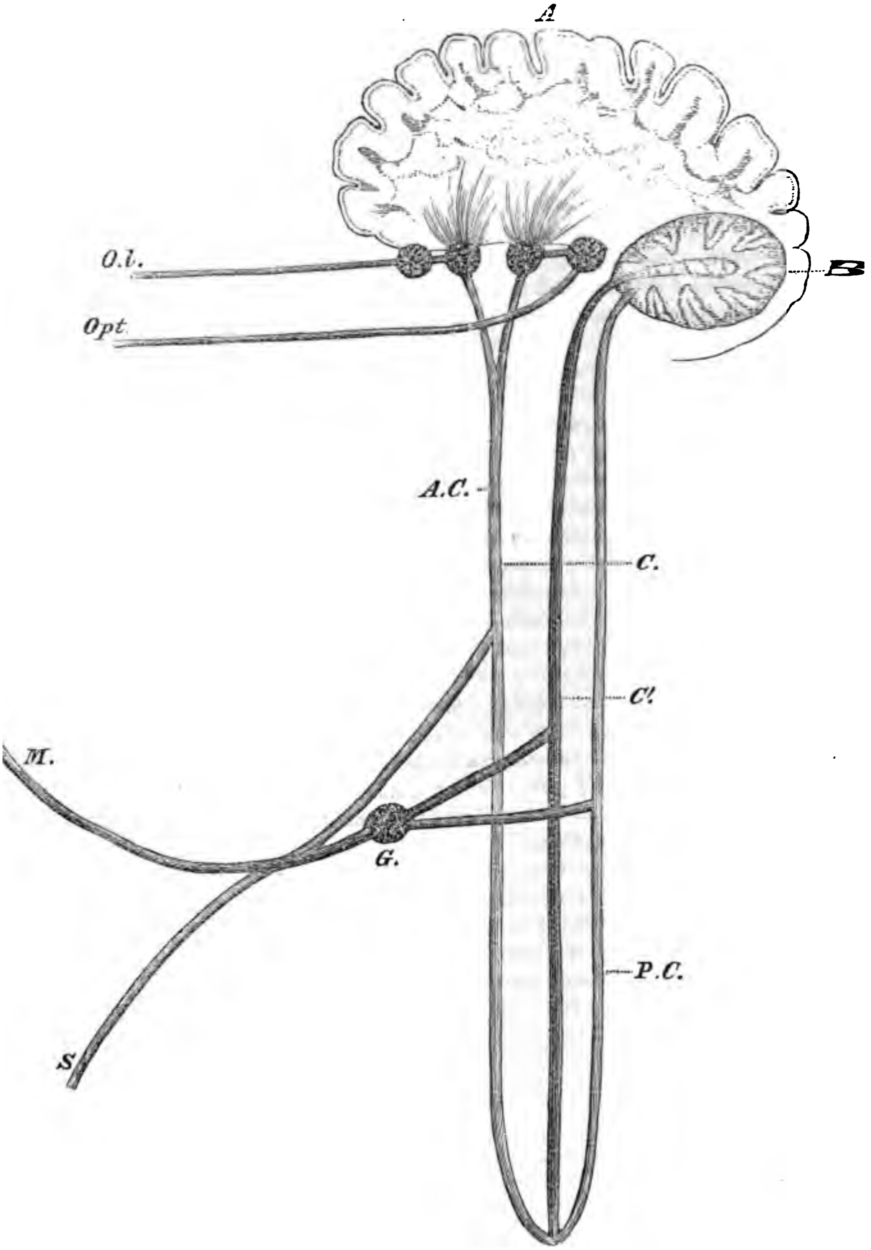
* When a certain number of these individual parts, lying in proximity, are habitually moved in concert with each other, occasion is given for the formation of a plexus. Thus, when the anterior and posterior wings of insects act together, or alternately, one becomes a surface of sensation to the other, and a plexus is formed between the ganglions of the one and the nerves leading to the muscles of the other, to connect them. Just so the brachial plexus relates to the fingers, and the ischiatic to the toes. In the plexus, the power of the fibre to transmit its own impressions independently of those united with it, is retained. In the ganglion it is lost. In other words, it sinks its individuality in the ganglion, but preserves it in the plexus. The plexus is merely a shorter route by which the sensitive surface of one segment, is made to unite with the muscles of another more directly than to send nerves round through the neighboring ganglions.

Now, there are three classes of sensations, by which the motions of animals are chiefly directed: the sensations of touch, smell, and sight. With regard to the influence of touch and sight, in this respect, we are made aware of the fact, by consciousness; and with regard to smell, by observation of the lower animals, particularly insects, many of which are directed to their food by this sense, and dogs, which follow it, when in pursuit of game. It might be thought by some, that hearing has as important an influence as the other senses; but except as a guide to the voice, any one who attends closely to the agency of this sense, will discover that when he undertakes to direct his steps by sounds, he has to make a great mental effort, and is very willing to substitute for it the sense of sight. If he hears the cars coming, or a horse galloping up behind him, he is sure to turn his head to see, before he avoids the danger.

Connected with each of these three classes of sensations, are two orders of motions, viz: the motions of the individual *part* on which the sensitive impression is made—as when the eye is moved from the impression of light upon it, or the segment or member of the inferior animal from an impression of touch on its surface—and the motion of distant parts, or of the body generally. If we touch the claw of a lobster, we commonly notice that the claw alone is moved, the main body of the animal continuing at rest. Many animals, still lower in the scale, are only capable of moving parts with reference to the whole body, being fixed by some portion of it, and thus rendered incapable of locomotion. Others, while they lie free, still move only parts. In fact, motion in animal life commences at the extreme parts, which are first acted on by the contact of substances floating in the medium surrounding them.

These three classes of sensations, with their two orders of motions for each class, give rise to six nervous circles, or, (to convey the idea better,) three double nervous circles, or apparatuses of union between the sensitive surfaces, and the muscles which accomplish the movements, directed by the sensations arising from the impressions made on those surfaces respectively. These six nervous circles, when joined together, constitute by far the greater part of the nervous system, and determine its general form and structure.



A, the cerebrum; B, the cerebellum; C, the spinal cord; C′, the central portion; AC, the anterior column; PC, the posterior column; SGM, the general nerve of touch; Ol, the olfactory; Opt, the optic nerve.

It is the object of the diagram to represent these circles apart from the nerves and minor apparatuses of union that complicate it, and thus enable one to see clearly how they concur in building up the nervous system. It will be at once seen, that I have taken some liberties with the location of the integral parts, and have not been particularly careful as to their relative size. But the connections are what, after careful study and examination, I believe to be the correct ones.

A is the cerebrum. Immediately beneath it, is Ol, the olfactory nerve, terminating first in the olfactory lobe, and secondly by commissure in the corpus striatum. Next, is Opt, the optic nerve, ending first in the optic tubercle, and secondly, by commissure also, in the optic thalamus. B, is the cerebellum. C, the spinal cord, with the three great divisions separated from each other, in order to show more distinctly their connections with the centres above, and with the spinal nerves below. SGM, is a spinal nerve, with the posterior nerve root, which is properly a commissure, divided into two parts : one running directly to the centre of the spinal cord, the other losing itself in the posterior column, and establishing through it a commissural connexion with the cerebellum. The anterior nerve root loses itself in the anterior column, and forms with it a similar connexion with the cerebrum. This arrangement differs from the one lately proposed by Mr. Grainger, who, in order to make the reflex function of Hall consist with Bell's doctrine, that the anterior nerve roots are alone concerned in motion, has undertaken to demonstrate their connexion with the posterior through the central portion of the spinal cord. It corresponds, however, with the observations of Bellingeri, who, without any theory to support, endeavored to trace these nerve roots to their final termination in the cord, and who succeeded in following the posterior fibres to the gray matter of the centre, but was unable to do the same with the anterior fibres. The theory of Grainger, more particularly as regards the termination of the anterior roots, is, moreover, opposed by eminent anatomists of Germany, and is admitted to be questionable by Dr. Todd, of London. Until, therefore, English and German microscopes agree in reporting the same facts, I shall consider myself free to sketch the connexions as they are found in the figure.

I have also taken the liberty of representing the cerebellum as in connection with the posterior columns and central portion alone, through the restiform bodies. A few fibres undoubtedly pass to the anterior columns, viz : the superficial cerebellar fibres of Solly, for which a reason may be given hereafter. But that portion, called by him the deep cerebellar fibres, which, he says, constitute one fourth of the corpora restiformia, and which lie along the cord immediately anterior to the groove made by the entrance of the posterior roots, belong to the posterior columns. It is sheer assumption to limit the posterior columns by this groove, and not the most ingenious one either ; for the groove would be formed, let them enter on whatever line, while a more central termination, admitting fibres to surround the roots, would be much better adapted for the communication of force, and is, in all probability, the true relation of the root to the posterior column. Why should the line of insertion of the posterior roots form the anterior boundary of the posterior column, more than the line of insertion of the anterior roots form the posterior boundary of the anterior column ? There is good reason to believe that the ganglionic root of the fifth nerve terminates in this part, instead of losing itself among the fibres immediately in front of it, which pass up to the optic thalamus, and which have been called the sensitive tract, from their supposed connexion with this nerve. Of course, I regard the supposition of this sensitive tract, as a work of pure fiction.

I shall now endeavor to evolve these six circles and show how they constitute the fundamental elements of the nervous system. Following the order in which the mind acquires the power of moving the limbs and members of the body, and associates these motions with the sensations, we begin with the general nerve of touch, SGM.

S, represents the fibres arising from the sensitive surface of the single segment or member corresponding to the claw of a lobster, the analogue of the finger or toe in man. These fibres pass to G, the ganglion, and there, by the action of the arterial blood which it meets, is made to unite with the fibres passing to M, the muscles that move that segment or member. Here, then, we have established the first nervous circle, through the nerve of SGM, between the sensitive surface and the muscles that move that surface. In this way provision is made for the moving of every distinct member or segment, which comes into relation with tactile impressions on the body as the centre of motion. But it is necessary that the mind should move not only that particular segment as directed by sensations arising from the tactile impressions made at S, but other segments, and reciprocally, this segment from impressions made on other points. If therefore it requires so much arterial blood or vesicular matter as is expressed by the ganglion G, to unite the fibres from S, with the fibres from M, an additional quantity of the same will be required to connect S with the fibres corresponding to M in other segments, and also to connect the sensitive fibres of other segments with the muscular fibres of this segment. This additional quantity of ganglionic matter is placed adjacent to the ganglion in the invertebrata and confounded with it, just as the sensori ganglia, at the base of the brain, are confused in the supra-œsophageal ganglion. In the vertebrata, it is transferred to a more convenient point as a centre, viz: the centre of the spinal marrow,—in the same manner that the above mentioned ganglia come out distinct and separate in this class of animals.* The centre of the spinal marrow then, by connecting the nerves of the several segments together, enables the mind to move any one segment as directed by sensations from impressions on any other. It is thus we eliminate the two first nervous circles, or the double circle for touch. SGM, the circle for the part, and $SC'M^2$, $SC'M^3$, $SC'M^{31}$, $S^2C'M$, etc., for all the parts.

In like manner, the fibres from the surface of smell pass to the olfactory lobe and are there made to unite with fibres passing to the muscles that move the organ of smell. This function, which is an important one in some of the lower animals, has, in consequence of the fixedness of the organ, become obsolete in man: hence, there is a corresponding diminution of the size of the olfactory lobes in man, and an absence of vesicular matter in them. But the mind not only is required to move the organ of smell by sensations arising from impressions made on it, but distant parts of the whole body: fibres therefore, are continued on from the lobe to the corpus striatum, and there, are made to unite with the muscles below, through the anterior columns and nerve roots. Thus is completed the second pair of nervous circles, or the double nervous circle for the sense of smell.

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* The optic tubercles would be placed in the same relative position to the optic thalami, and the olfactory lobes would stand relatively to the corpora striata, as the ganglions on the posterior nerve roots are situated with reference to the centre of the spinal cord, were the eye and nose at right angles to the axis of the body.

Finally, the fibres from the retina pass to the optic tubercle, and there unite with fibres which pass to the muscles that move the eye. And it may be mentioned, as a strong confirmation of the theory, that the third nerve, according to Carpenter, can be traced into the optic tubercle. A still more striking confirmation, though a little out of place, may be alluded to here. I mean the fact that the brachial plexus and the ischiatic plexus, which send nerves to the five fingers and five toes respectively, come off each from five ganglions of the spinal cord.

It is requisite, however, as in the cases of smell and touch, that the whole body, the hands, and the feet, as well as the eye, should be moved under the direction of sight. The muscles that move these parts must therefore be connected with the eye. Fibres are accordingly continued from the tubercles to the thalamus, and, by the action of the arterial blood they there meet with, are made to unite with other fibres, which pass along with those from the corpus striatum, through the anterior column and nerve root, to the muscles of the segments ; completing the six nervous circles for the three classes of sensations, and two orders of motions, by forming the third double circle, or that for sight.

If now, the cerebrum and cerebellum being absent, we suppose the spinal cord with its nerves raised up to a horizontal line with the four sensori ganglia, we shall have the nervous system, as it is found to exist in the lowest of the vertebrated animals. It is natural to infer, therefore, that sufficient power exists in the several centres to maintain the connections between the muscles and the sensitive surfaces, so as to enable the mind to accomplish the simple motions of those animals. But in proportion as they rise in the scale, and their limbs become developed, and their movements in every way more complicated, an increase of central power is manifestly wanted. To supply this demand, the cerebrum and cerebellum begin to be developed, and keep pace with the growth of the limbs and the progress of the animal, in the scale, towards the erect position. The origin of these organs is in this wise :

The cerebellum is the further development of the centre of the spinal cord, and whatever is effected by this last, is effected by the cerebellum in greater perfection, and much more abundantly. It may be defined to be, the great central organ, which unites all the nerves of touch with all the muscles, and thus enables the mind to govern the motions of the body generally, when directed by the sensations of touch.

The cerebrum is also the further development and coalescence of the corpora striata and optic thalami, and, in like manner, a magnifier of their functions. It may be defined to be, the organ which the mind makes use of to govern the motions of the body, when directed by the specific senses of sight, smell, &c., and is connected with the organs of the senses by their nerves, and with the muscles of the body, by the anterior columns and anterior nerve roots.

It will be seen, on a review of what has been now stated, that the ganglions on the posterior nerve roots, correspond in function with the optic tubercles, and the olfactory lobes, and that the central portion of the spinal cord corresponds with the ganglionic part of the corpus striatum, and of the optic thalamus, and the fibres which terminate in them ; while the posterior column agrees with the fibres which pass through these bodies to the cerebrum, and which constitute by far the largest portion of the anterior column of the spinal cord.

We thus find in the anatomy of the cerebro-spinal nervous system, the conditions of the theory fully realized. The principles require that a pair of ganglionic bodies should be found for each of the three classes of sensations, corresponding to its two orders of motions, and we find them connected with their appropriate nerves, and answering to the importance of the respective classes of sensations, as directors of motions, by their relative size. Moreover, in finding these bodies, we exhaust the fundamental and constant elements of the nervous system, leaving no part unaccounted for.

Legitimate analogy justifies the extension of the same principles to the interpretation of the offices of those nerves to which, from the absence of consciousness of the sensations and volitions exercised through them, they cannot be directly applied. In such a nerve as the par vagum, for instance, it is reasonable to infer that the jugular ganglion unites the fibres from both the muscular and sensitive surfaces below it, and thus not only enables the different portions of the respiratory surface to act in concert, as in coughing and ordinary respiration, but also brings the stomach into sympathy with it, as when a fit of coughing ends in vomiting, or cough itself arises from a disordered stomach. While the more distant connexion between these surfaces and the external muscles of respiration and diaphragm, is maintained by the extension of the par vagum to the centre of the cord, and its union then with the spinal accessory, phrenic, and intercostal nerves, etc.

So, in like manner, the interposition of the ganglionic system among the muscular tubes, as the intestines and blood vessels, is to establish connections more or less remote, and provide for those motions which, in contradistinction to the true peristaltic motions, take place when the impressing cause is at a distance from the muscle to be contracted, as when the contractile motions of the gall ducts or of the blood vessels of the liver are excited in consequence of the impression of substances introduced into the stomach, or when vomiting takes place from intussusception, or perhaps from sympathy with the kidney or uterus. The general excitement of the whole vascular system, from local irritation, may also eventually be found to take place through the sympathetic. It is found by experiment, that division of these nerves paralyzes the blood vessels to which they lead. The office now assigned to the sympathetic, that it harmonizes the action of the organs of secretion and nutrition, equals, in precision and definiteness, the one assigned to the cerebellum, of co-ordinating and combining the muscular movements. These expressions serve to show the amount of knowledge likely to be attained by those who overlook the suggestions of analogy, and of structure, and seek only for some specific purpose in the function of a part. He would receive little credit for his insight into the philosophy of the electric telegraph, who could say no more of it than that it was to harmonize and combine the commercial operations of the principal cities of the union.

The view above given, I claim to be the true and complete physiology of the brain and nervous system. And while its general simplicity and consistency entitle it to consideration, not the least of its recommendations, is, its enabling us to attain a position, from which we can see the inconsequence of every inference from observation and experiment, on which has been grounded the doctrine of sensitive and motor nerves. When we contemplate the different offices of the cerebrum and cerebellum, we see at once how the idea arose among the ancients, of the two systems of sensitive and motor nerves, while nothing could be more unfounded. As both organs were employed by the mind in the execution of motions, the loss of motion would follow grave disease of either of them, while the loss of sensation would be attendant on disease of the cerebellum alone. The permanent loss of motion so much more frequently than loss of sensation, is to be attributed to the well known fact, that effusion of blood takes place in the cerebrum much oftener than in the cerebellum ; while the loss of both of these powers first, is to be attributed to the mind's employing habitually both of these organs, to keep up a state of tension on all the nerves, and to its not being able, immediately on the shock of a grave injury to one of them, to excite that increased activity of the other, which is requisite to enable it to perform the function originally associated with it.

When, also, we adopt the idea of the mind being present in some mysterious manner to all the organs, instead of being located in the brain, we are prepared to appreciate the manner in which Sir Charles Bell was imposed on by his experiments. We see by the diagram, that originally the mind contracts the muscles at M, in consequence of a sensation arising *after* a physical impression made at S, has been transmitted up to G, and down the nervous cord GM. At first, during the whole time that the mind is employed in associating its muscular contractions with the sense of touch, these muscles, it is probable, are never contracted in any other way. The mind, therefore, from the long habit of experiencing the *true* sensation after the physical irritation along the nerves, affects itself with an *illusory* sensation, and contracts the muscles accordingly, on any such irritation reaching it in the same way. Just as when, having habitually experienced the true sensation of light after the normal stimulation of the retina, it affects itself with a false sensation of light, let that organ be physically irritated in whatever way. The only difference is, that we are conscious of one fact, but not of the other. An instinctive association (as I have shown at more length at page 51,) is thus formed between the physical irritation of the nerve and the contraction of the muscle, which withdraws it from the influence of the will. Now, if the anterior root be physically stimulated, as in the experiments of Bell, the stimulation is propagated down the cord to M, and the muscle contracts in the same way. The inference, therefore, drawn from this phenomenon, that a motor power is inherent in the nerve, is not a necessary consequence.

I shall next advert to the experiments of Muller, by which he is said to confirm Bell, previously invalidated by the experiments of Magendie. This author objected to Magendie, that he employed too strong a galvanic force to the posterior roots ; and that the current was transmitted down to the muscles, and excited their contractions. He, therefore, having cut off the roots close to the cord, in the frog, where they are unusually long, applied mechanical irritation, (which is known to be less certain than galvanic,) and the feeble current arising from a single pair, to the distal extremities. No contractions of the muscles followed in either instance ; and he inferred that these "experiments leave no doubt as to the correctness of Sir C. Bell's theory." Now, on the surface of things, in coming to this conclusion, this distinguished physiologist has violated the fundamental principles of logic. When the anterior and posterior roots are separated from the cord, in what do they differ from each other ? Manifestly, in nothing, but in the one being possessed of a ganglion, and the other not. To this difference in circumstance, therefore, according to the second canon of Mill, is to be attributed the difference of result, in the experiments in question. This objection to Muller's sweeping conclusion would be sufficient to overthrow it, were there no positive facts to prove the influence of the ganglion in hindering the transmission of physical irritations through them. The fact, however, is beginning to be recognized, as the following quotation from Paget's Report on Physiology, for the year 1846, will prove: "The absence of contraction of the palato-muscles when the nerve is irritated, may be connected, as M. Longet suggests, with the filaments having to pass through a *ganglion*; in the same manner as irritation of the third pair often fails to produce contraction of the iris." All this is what might be inferred from our view of the structure of the nerve. The ganglion is the natural terminus of the fibres below it. Care is therefore taken that the anterior root should enter beyond it. Tension must be exerted through it, overcoming as it were, from the spinal cord, its own force, or physical impulses can be made with great difficulty to extend to the nerve below. Hence, the powerful battery of Magendie could rarely excite these contractions, while the mechanical irritations, and single pair of plates of Muller, failed altogether.

Finally, the experiments of Kronenburg, instituted to account for the occasional appearances of sensation when the anterior nerves were irritated, border on the ludicrous. They serve, however, to illustrate the shifts and expedients that men will resort to, to prop a theory which they hope to be the true one, and must therefore be noticed. This experimenter made a *crochet* cut at the junction of the anterior root with the nerve, about half a line in depth, as he tells us, to the effect of silencing all signs of sensibility when the anterior root was irritated. Hence, he concluded, that he had cut off a loop of fibres which entered this root, from the posterior, and were therefore sensitive fibres. If such fibres exist and lie so near the surface, it would be an easy matter to demonstrate them. There can be no doubt that the signs of sensation witnessed in the subjects of these experiments, were due to the spasmodic or cramp-like contractions of the muscles excited, and the pain consequent thereon; * which, as they were only occasional when the nerve was in its integrity, might obviously cease to be manifested when it was thus wounded.

In concluding this outline of a new view of the physiology of the nervous system, I would add, by way of bespeaking for it your favorable consideration, that it does not, like the present system, account for one class of motions by one cause, and another by a different one, but reduces all the forms of muscular motion to the same fundamental law. It does not assign different, and discordant functions, to the same organic structures, but to the ganglionic substance wherever it is found, and to the medullary substance wherever that is found, it attributes to each a single office, and one corresponding to its mechanism. It neither multiplies secondary, nor calls into existence occult causes, but blends the natural inferences from mental phenomena, with the natural inferences from sensible facts, regarding them as of equal authority. It builds up the nervous system in its natural order, and finds a reason, and a necessity, for every one of its constituent parts, and binds them together in a systematic unity and fullness of proportion.

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* This is also the opinion of M. Sequard.

APPENDIX
ON
HYDROPHOBIA.

What I have to say on Hydrophobia will consist mainly of two short papers originally published in the Boston Medical and Surgical Journal, with a few additional remarks which have been suggested to me since the publication of the last one. Although what is peculiar to myself in the mode of viewing this disease, may be considered as springing in a great measure from the ideas in regard to the nervous system expressed in the foregoing pages, I am not so sanguine as to stake their claim to general acceptance on the presumption that they will prove the instrument to cure this formidable disease. They are already proved by the reasonings with which they are accompanied; but so desirable a practical result would set the seal of confirmation to them in the most gratifying manner, furnishing as it does a renewed instance of the general fact that all truth is for the benefit of mankind. I therefore feel myself justified in my pertinacity, when, for the third time, I endeavor to call the attention of practitioners to a pathology and mode of treatment of hydrophobia never as yet acted on.

The first article is extracted from the Journal of February 21, 1849, as follows:

To the Editor of the Boston Medical and Surgical Journal.

Dear Sir,—In reading the account of the late case of hydrophobia in your Journal, my attention was most forcibly arrested by the quotation in the last paragraph, from Dr. James Johnson; so much so, that I have thought fit to transcribe it again, with a view of making it serve as a text or preface for a few remarks on the pathology and treatment of this intractable disease.

"We must conclude," he says, "that it cannot be denied, but that the most evident indications of inflammatory action attend the symptoms, and distinguish the pathology of hydrophobia; that we have often inflamation of the œsophagus, pharynx and larynx, and occasionally of the brain and spinal cord; yet it is generally admitted that these appearances are more the consequence than the cause of the disorder, and that although frequently present with, they are by no means essential to, the existence of hydrophobic action."

When we consider the frequency of traces of inflammation of the mucous surface of the throat, and the prominence of spasmodic action in those muscles, whose normal actions are excited by impressions on that surface, the question naturally arises, whether, supposing it to be a consequence and not the cause of the disease, it may not still be owing to this complication that the disease acquires that habit of intense spasmodic action which constitutes its danger and intractability. The inflammation of the skin in confluent small pox, is not the cause of the disease; yet it is that which, in nine cases out of ten, renders the disease fatal. Nor can we see any reason for the assertion of Dr. Johnson that this inflammation is not essential to the disease when fully developed. That distinct traces of inflammation in these parts have not been discovered in every case of hydrophobia, may be accounted for, in some instances, by the disease having proved fatal before the anatomical characters of inflammation were developed; in others, mistakes may have been made as to the identity of the disease; and doubtless in some instances, they may have been overlooked—the examinations having been conducted by persons unaccustomed to detect the nicer shades of inflammation. I question whether every one could detect evident marks of inflammation in the larynx, in hooping cough, at an early period; yet that the violent spasmodic action of the respiratory muscles in this disease, is owing to an inflammatory condition of that organ, hardly admits of a doubt.

The analogy which exists between this and other specific diseases that have a stage of incubation, confirms this opinion. They all exhibit a tendency to the same parts, whether they are communicated by animals of the same or different species to one another. Now in the dog, there can scarcely exist a doubt that the parts about the throat are primarily diseased in cases where it arises spontaneously, and secondarily where it arises from the bite of another dog. And it were natural to suppose that the same parts in man would be affected in the same way.

If the disease were a general, instead of a local one, it would be impossible to account for the appearance of inflammation in the bitten part, which takes place so often and after so long a period of time. In this respect the virus acts very much like the virus of smallpox when inoculated into the system. Here we have, in the first place, a period of incubation; secondly, a period of local inflammation; thirdly, a period of reflected irritation or constitutional excitement; then a second period of local inflammation; and lastly, the constitutional effects of this. Now in hydrophobia we have the same series, only they seem more to run into each other—that is to say, the constitutional follow much sooner on the local symptoms. On the other hand, we see in vaccination the first mentioned virus, by a very slight modification, blunted in its action, and the constitution successfully resisting the two last terms of the series. And if this difference of results, viz., the abortion of the secondary inflammation, follows from this morbid poison being a little slower in its operation in the last case, that of rabies being confessedly more active, it is easy to conceive that a slight increase of its activity might produce effects the very reverse, and give rise to a secondary, without any obvious primary inflammation, and thus account for the comparatively few cases where no preliminary symptoms are complained of in the bitten part. Perhaps the strongest evidence of its being a general disease, is the extreme irritability of the whole surface of the body. But, when it is considered that this is later in appearance than the affection of the throat, that it must naturally arise from an irritation of the spinal marrow, and that dissection reveals traces of inflammation in the spinal marrow less frequently than in the mucous surface of the throat, and that, too, in that portion of the cord where the nerves of deglutition and respiration terminate, its occurrence, as one of the consequences, is almost demonstrated.

Having been impressed with these views for some time, I would respectfully suggest to physicians who may be called to treat hydrophobia, that it is a disease of a mixed local and general nature, having two foci of inflammation and constitutional irritation, a primary and a secondary one; and that, while the constitutional symptons should not be neglected, the main hope of arresting its dreadful fatality consists in applying remedies to these seats of inflammation: and I would farther suggest, from the known efficacy of nitrate of silver in various diseases—such, for instance, as erysipelas, a local disease with severe constitutional symptoms; in small pox, the pustules of which it stops when early applied; and in gonorrhœa, which it likewise aborts (the two last being diseases which, like rabies, arise from specific animal poisons)—that its application in a strong solution, to the whole surface of the pharynx, fauces and mouth, as far as practicable, at an early period, (that of commencing spasm,) affords a hope of successful, while it can be productive of no injurious, results.

I am not aware that anything of the kind has ever been attempted. Two cases of recovery, spoken of in Druitt's Surgery—one by the administration of acetate of lead, the other by profuse salivation—may have been the result incidentally of the local effects of the lead and the mercury on the mouth, while being exhibited. With the exception of cauterizing the wound immediately after the bite, and some imaginary vesicles under the tongue, this disease has been uniformly treated as a general one, the symptons having been attacked, while the cause has been overlooked.

And with respect to the general treatment, the substitution of chloroform for the old and approved methods of allaying spasmodic diseases, will hardly, I think, be found to be an improvement. And in this disease the difficulty of using it, and the rapid subsidence of its effects, will form an effectual bar to its long-continued employment. In the case referred to, it evidently occasioned the death of the patient. A tonic instead of a lowering plan is indicated. If any medicine is administered by the mouth, quinine, in large doses, would be worth trying. The act of swallowing should not be excited without a sufficient reason; and the stomach should be let alone as much as possible, that it may be able to digest light nourishment, which should be administered from time to time if the disease is protracted. The muscles of deglutition would be excited less to action, if the stomach tube could be introduced for the purpose of injecting liquids. The surface to which remedies should be applied, is the mucous membrane of the large intestines, and care should be had that this membrane be kept in a state to be favorably affected by these remedies. Laudanum injections, in teaspoonful doses, at intervals so as to keep the patient in a state approaching to narcotism, and if these fail, tobacco, in the form of smoke, which I have found to be a safe and efficient antispasmodic, more slow and persistent in its action than the infusion, and not so prostrating. Some slight advantage might follow from an opium, belladonna, or snuff plaster, to the throat or nape of the neck.

It may be regarded as somewhat obtrusive, for one to propose a plan of treatment for a disease, a case of which he has never seen. But from the comparative rarity of hydrophobia, the opportunities to witness it that happen to the most favored will rarely give them a title to claim anything more than a negative experience. In a disease so uniformly fatal, any experiment that affords a *faint* prospect of success is justifiable. And I would add that the increase of rabies of late in New England, renders it obligatory on those physicians who may meet with it, to give an account of their cases as soon as convenient; and instead of publishing them at the South, or at the far-off West, communicate them to the Journal most extensively read by their New England brethren.

Second article, from the Journal of Jan. 25, 1854 :

The remarks of Dr. Coxe, of New Orleans, in a late number of the Journal, recall to mind some observations published several years ago on the same subject. Hydrophobia, frightful as is its aspect, is fortunately so rare, that few physicians may expect to see, much more to have an opportunity to treat it. If any one, therefore, is in possession of views in regard to it, differing from those of the profession at large, he is not likely to have an opportunity of bringing them to the test of observation or experiment himself; and is justified in recommending them to his professional brethren, even in a crude state, so long as universal fatality attends the recognized mode of treatment. In vol. 40 of this Journal, pages 55—58, I endeavored to call attention to the mucous membrane of the mouth and throat as the chief source of the morbid phenomena in this disease. Since that time, several cases have been published, but in no one, is there reason to believe, were the suggestions put forth by me, thought sufficiently worthy of notice, to influence the treatment in the least. It was always found best to pilot the patient over the road to sure destruction, rather than to deviate from the beaten track.

To my mind, the evidence that there is specific inflammatory irritation in the mucous membrane of the mouth and pharynx in this disease, stops little short of certainty. The poison, in the first place, comes from the mouth of the dog, and, following the general law of morbid poisons, especially of those that have a period of incubation, it is most likely to locate itself in a similar part in man, as well as in other animals. Secondly, appearances of inflammation after death, though not constant, are much oftener found here than anywhere else. Thirdly, the spasmodic symptoms commence in those muscles, whose nerves are in immediate connection with the surface in question; and are such as would naturally arise from reflex irritation of those nerves. This fact has so impressed the minds of some pathologists that they have fixed upon "the nervous arcs that pertain to the throat" as the seat of the disorder.* And it is remarkable, that all attempts to locate the disease have revolved about this point as a centre. Fourthly, if the disease is communicable by the saliva of man, as there is reason to believe, then there must be a perverted action of the salivary glands themselves, or of the surfaces on which their secretions are poured out; and this action must be a specific one, inasmuch as the secreted product, when inoculated anew, uniformly gives rise to the same set of symptoms.

Convulsive disorders can be oftener traced to irritating impressions on membranous surfaces, than to other sources ; and it is worthy of remark, that these impressions are slight in degree, compared with those which attend well-marked inflammations. Thus, tickling the skin produces uncontrollable laughter ; itching of the trachea, cough ; of the nose, sneezing ; all of which are of a convulsive character. Dentition, as well as indigestible substances in the alimentary canal, excite convulsions in children, and the latter cause often brings on the epileptic attack in adults. Tetanus, when arising from a wound, is most likely to occur when healthy inflammation fails to take place, or after the wound is healed. It often appears to be owing to a want of concentration of the inflammation on the part. That which takes place from strychnia, is owing to the impression which this substance makes on the alimentary canal. The idea that it arises from its being absorbed in the blood, has no foundation, except in the imagination of professed pathologists. Chorea, even, may be noticed to follow upon the disappearance of a chronic cutaneous eruption, or the healing up of a scrofulous ulcer. In many cases it undoubtedly depends on some irritation of the mucous membrane of the stomach and bowels. And the application of the cold bath to the skin, or of zinc to the internal surface, are the chief means relied on in this disease. The strongest reflex actions are excited by applications to the skin. It is doubtful, whether a single unequivocal instance of convulsions being caused by a poison circulating in the blood, and acting directly on the nervous centres, can be produced. The several poisons of measles, of small pox, and of hydrophobia, lie in close contact with the blood during the whole period of incubation of each of these diseases. But neither febrile nor convulsive symptoms show themselves, until they begin to modify the vitality of the tissue in which they are deposited. The physiological law is, that muscular contractions follow impressions made on surfaces, and convulsive or spasmodic movements are aberrations, not contradictions, of this law. The affections of the nerves and nervous centres are secondary.

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* Watson.

The disease which presents the closest analogy to hydrophobia, all things considered, is hooping cough. Although in times past, there has been much dispute and speculation in regard to the seat of this disease, the weight of authority is now in favor of its being a specific inflammation of the mucous membrane of the larynx and trachea. To this inflammation, or to the peculiar viscid secretion which is its product, the violent spasmodic cough is owing. What hydrophobia is to the nerves of deglutition, hooping cough is to the nerves of respiration. The chief point of difference is, that in the former the spasms extend beyond the the sphere in which they originate, while, ordinarily, in the latter, they are confined to it. Now if in the one case they arise from the condition of the mucous surface, why not in the other ?—especially as there is equal proof of inflammation in each. The appearances of inflammation in the trachea, in those who die in the early stage of hooping cough, are scarcely if any greater than in the mouth and pharynx of those who die in hydrophobia.

If this is the true pathology of hydrophobia, the want of success in its treatment may be easily accounted for, without supposing that the disease is necessarily, from its very nature, incurable. Remedies have been applied to *symptoms universally*, (always excepting those cases where the radical cure was attempted by smothering the patient,) while the cause of those symptoms has been overlooked. It is manifest that the first indication is, to modify the diseased surthemselves out, and run the risk of seeing my patient succumb to them, or invent a treatment for the occasion. My reasoning, which I mention for the benefit of those who contend that practical medicine never advances, except empirically, was in this wise: strychnine is the most powerful excitor of muscular spasms now known; tobacco is the most powerful allayer of spasmodic action also known,—and I resolved to meet Greek with Greek. But I was afraid then to leave my obstetric case long enough to carry the plan into effect. The double prescription of the morning was therefore renewed, and I again left. At half past ten in the evening, I found myself at liberty, and having procured some tobacco and a pipe, with a gum elastic tube, lost no time in returning to my patient. The spasms appeared as frequent and severe as in the morning. She had taken in the course of the day, as nearly as I could judge, twelve grains of opium without effect. The tube was now introduced into the rectum and passed through the sigmoid flexure into the colon. With the assistance of women, two pipes of tobacco smoke, making considerable allowance for waste, were passed through it. We had commenced on the third, when she expressed herself as feeling easier; after waiting some minutes and finding no return of the spasms, the tube was withdrawn. She soon fell asleep, and I went home without any feeling of uneasiness respecting the quantity of opium that she had taken, or the prostrating effects of the tobacco. On my return in the morning, I found that she had had a comfortable night, having been entirely free from spasm, and that the great object for which the strychnine was given was fully accomplished; every symptom of palsy having left her. There was, however, remaining a great irritability of the system to all sensitive impressions. Any sudden sound, a bright light, a flaw of wind such as would be made by the opening of the door, or the least touch, would occasion slight muscular contractions over the whole body. This state, so strikingly like the general condition of the system in hydrophobia, continued, though gradually subsiding, more than a week.

The case was interesting in several points of view. Was there a cumulative effect from the quantity previously taken? Was it the three days' interval, or the addition of the camphor, that made a smaller dose than that which she had been in the habit of taking, so suddenly active? Camphor has lately been proposed as an antidote to this poison. Could not such an operation be reconciled with the idea of its increasing its activity in the manner prescribed? I have thought, in giving camphor with opium and other agents, that it seemed to make an addition, in some instances, to their peculiar operation. But I do not feel competent to speak decisively. Others may be in possession of facts which will enable them to throw light on these questions. The object that I have had in view in giving publicity to the case, is to illustrate the fact, that symptoms precisely of the character of hydrophobia, can be relieved by tobacco smoke. There is also considerable evidence to show that they have been relieved by lobelia, which, from its affinity to tobacco, is not improbable.*

In striking contrast with the mild, anti-spasmodic effects of the smoke, here witnessed, were the consequences of administering the infusion in a case of tetanus, which came under my charge, a few years afterwards. A small sized, but very muscular man, while partially intoxicated, crushed a glass tumbler with his hand, and wounded the space between the thumb and fore-finger. This piece of fool-hardiness occurred in the forenoon. During the greater part of the day afterwards, he stood nearly up to his knees, in the tide-water, scrubbing the bottom of his fishing smack. Towards night, he complained of pain in the wound, and stiffness of the arm. At 10, P. M., I was called and found the spasms extending up the arm to the shoulder, and soon across the breast to the other shoulder and arm. On examining the wound, it was found dry and ragged, and evidently without action. It was touched with lunar caustic, and a warm tobacco poultice was directed to be applied. Opium was given internally freely, and efforts were made to induce perspiration. By morning, the spasms had extended over the whole body, and were very violent, giving rise to complete opisthotonos. A scruple of dry tobacco was now infused in about a half pint of water, and given in enema. This produced total relaxation of the muscular system, with vomiting and purging, attended with a feeble pulse and cold perspiration. As he recovered from this state, the spasms returned, and the same enema was repeated with the same effects. After some four or five such repetitions, I began to feel anxious about the prostrating effects of the remedy, and lessened the dose about one third ; but this did not control the spasms. We were therefore obliged to return to the former quantity ; and I soon found them lessening in frequency, and by the third day from their commencement, he was decidedly convalescent. I now looked at the wound, and found it suppurating kindly. For the last twenty-four hours, a common emollient poultice had been applied, instead of the tobacco one, he having complained that this last gave him pain.

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*See an article in the Boston Medical and Surgical Journal, vol. 40, p. 101, on a method of treatment of Hydrophobia with lobelia by Dr. Benaiah Sanborn, of Sanbornton, N. H.

In these two cases, we see illustrated the different effects of the same remedy, according to its mode of administration. Were I to have another case like the last, I should use the smoke in preference to the infusion. In all the cases of severe colic, strangulated hernia, &c., that I have had for the past twelve years, I have made this the last resort. And I believe, that were it adopted within any reasonable time, not a case of strangulated hernia would ever require an operation. And, in not a single instance, have I seen anything like the prostrating effects which were witnessed in the above case of tetanus.

The application of the nitrate of silver was made to the wound on the principle of concentrating action on the part. Tetanus occurs, when a certain degree of irritation exists, which fails to induce a sufficient restorative action in the part, and which appears, in consequence, to be reflected, as it were, on the nerves. Quite an amount of evidence might be collected from the journals and other sources, tending to show the power of the nitrate to allay, when applied to an irritated surface, the spasmodic action which appears to be a reflex of that irritation. During the present season, I have applied it twice to punctured wounds ; one penetrating to the knee pan, from the iron tooth of a rake, and the other from a rusty nail, in the foot ; in both of which premonitory symptoms of tetanus were urgent ; and, although other means were also used at the same time, yet the quick subsidence of the symptoms after the application, gave reason to suppose that it had the chief share in bringing about this result.

The nitrate of silver is the best application to the wound immediately after the bite. It is far superior to suction, not only in this class of cases, but also in the bites of venomous animals generally. The bite of the rattlesnake gives rise to a malignant erysipelas, a local disease, and should be attacked by local means.

ERRATA. Page 40, eleventh line from the bottom, read "circumlocution" for "circumvolution."

Page 57, third line from the top, for "neuroy aisthetikoi, and neuroy kinetikoi," read "neuroi aisthetikoi, and neuroi kinetikoi."

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